CONNECTICUT RIVER FLOOD CONTROL

BEAVER BROOK

DAM AND RESERVOIR

BEAVER BROOK NEW HAMPSHIRE

SUPPLEMENTARY RECONNAISSANCE REPORT

DRAFT COPY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.

MARCH 1964

ENGCW-PD (12 Mar 64) 1st Ind
SUBJECT: Supplementary Reconnaissance Report, Beaver Brook, Keene, New Hampshire

HQ, DA, CofEngrs, Washington, D. C., 20315, 15 June 1964

TO: Division Engineer, U. S. Army Engineer Division, New England
WALTHAM, MASSACHUSETTS 02154

1. Further Detailed Study is authorized under Section 205 of the 1948 FCA as amended. Preparation of a Detailed Project Report will be subject to the comments in the following paragraphs.

2. It is noted that paragraph 5 of the NED letter and paragraph 25e of the report indicate that the need for water-oriented recreation in the area will be satisfied by the nearby Surry Mountain and Otter Brook Reservoirs. Paragraphs 24f and 25e of the report indicate that if the need for water supply in the project is unduly extended or does not develop, recreation would then assume greater importance. In this connection statistics tend to show that when public access is provided to inland bodies of water of relatively stable levels, the public will utilize them to near capacity irrespective of nearby similar facilities, and particularly in densely populated areas. Accordingly, it is suggested you make a more detailed analysis of the prospective recreation demand. Further, in consideration of the purpose and intent of the Fish and Wildlife Coordination Act and Section 207 of the Flood Control Act of 1962, and the increasing demand for public outdoor recreation, there is some doubt that construction of a dry reservoir is generally consistent with planning for optimum long-range use and development or control of water resources. The difference in cost between single-stage and two-stage construction appears within a reasonable contingency factor. Since there seems to be doubt as to when the project may be used for water supply, and since local interests may provide for recreation after second-stage construction, further consideration should be given to constructing the project in one stage with the water-supply storage used for recreation and flood control until needed for water supply. It is believed these interim benefits might offset the small additional cost of single-stage construction.

3. Re: Par. 25c, page 10. This paragraph states that P.H.S. after conference with State agencies came to a tentative conclusion on 17 April 1962 that low flow augmentation is not necessary for the Keene area. On 4 October 1963 at Hartford, Connecticut, at a hearing held on pollution abatement by the Natural Resources and Power Subcommittee of the Committee on Government Operations it was brought out that there is a considerable immediate and future need for low flow augmentation in the Connecticut River of which Beaver Brook is a tributary. Also, at that hearing the

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Division Engineer testified that a comprehensive study is underway in the Connecticut River Basin which will place a strong emphasis on upgrading the quality of water under authority contained in Public Law 87-88. In view of developments since April 1962, it is recommended you reexamine the need for and availability of water for quality control in Beaver Brook as it would affect the Connecticut River and fit into the comprehensive plan for water resources.

4. Re: Par. 11, page D-5. The delay until year 16 of need for water supply storage depends upon an economic advantage in constructing well No. 4 at year 10. The construction of well No. 4 represents a sizable investment with an economic life to year 16 when reservoir storage would be provided. The availability of a water source for well No. 4 is not established. The estimated cost of the well should be carefully reviewed. It is believed that further examination of the longer range value of reservoir storage may show advantages that outweigh those credited to well construction. It is suggested the discussion of well No. 4 include a comparison between wells and reservoirs on the basis of unit cost per M.G.D.

5. The cost allocations as presented are satisfactory for economic comparisons. However, it should be made doubly clear that those costs are present worth values. It is recommended that: (a) additional information be included to indicate the initial separable costs subject to interest during the period of non-use and their investment value at time of expected use; (b) an estimated cost allocation at the time of completion of project should be included to show local interests actual costs; and (c) the local costs of LE and R/W be divided between flood control and water supply. Technically water supply would not bear all those costs.

6. Re: Pr. 3 NEDED-D letter of transmittal dated 12 March 1964. This paragraph proposes to assign costs to water supply for proposed first stage development to the Government subject to future re-apportionment when the second stage is constructed. It should be understood that these costs would be interest free for ten (10) years and interest on the balance would accrue until year 16 when 2nd stage construction is anticipated or some other period beyond 10 years after the project first goes into operation.

7. Par. 32, page 15. This paragraph states that annual charge to F.C. does not include annual charges for extra lands, etc. This statement is not accurate as the costs are included in cost allocation from which flood control cost is computed.

8. Par. 8d (2), page B-14. The last sentence of the paragraph should be clarified. It apparently is intended to indicate that storage the total cost for storage, pipe line and filter plant.
cost is about ¼

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9. Par. 8d (4), Page B-15. This paragraph is not accurate. It should say the present worth of the allocation to water supply, etc. Costs to water supply under the two stage procedure would consist of specific costs of first stage construction with interest from year 10 to 16 plus second stage costs, joint and separable, allocable to water supply.

10. Re: Page C-5, Table C-III. The value of $50,000 for clearing for single purpose water supply is questioned. A slightly larger flood control only project shows $5,000 in clearing costs. Also see Table No. D-11, page D-8, concerning clearing costs.

11. Page 13, Table I, Note 4. It is to be noted that the $131,000 is a direct cost for making provisions for future water supply and does not include a proportionate share of E&D and S&A costs.

12. Paragraph 34: As stated above, it is expected that ultimate use of the reservoir will include provisions for recreation. Since local interests will be operating it, free public access to the water areas should be made a requirement of local cooperation.

13. The Division Engineer should notify the concerned Members of Congress of this authorization to undertake further studies.

14. The following work allowance is established to prepare a Detailed Project Report pursuant to Section 205 of 1948 FCA, as amended:

Location	Code 902-	Amount
Beaver Brook, New Hampshire	516	$75,000

15. Allotment of $75,000 under appropriation 96X3122 Construction, General will be sent by separate communication.

FOR THE CHIEF OF ENGINEERS:

Incl
nc, 3 cys w/d

ROBERT C. MARSHALL
Colonel, Corps of Engineers
Assistant Director of Civil Works
for Atlantic Divisions

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM 54, MASS.

ADDRESS REPLY TO:
DIVISION ENGINEER

REFER TO FILE NO.

NEDED-D

12 March 1964

SUBJECT: Supplementary Reconnaissance Report, Beaver Brook, Keene, New Hampshire

TO: Chief of Engineers
ATTN: ENGCW-PD
Washington, D. C.

1. There is submitted herewith, for review and comment, draft of Supplementary Reconnaissance Report for Beaver Brook, Keene, New Hampshire. This report contains the additional information requested in 1st Indorsement, Subject: "Reconnaissance Report, Beaver Brook, Keene, New Hampshire", dated 20 August 1963.

2. The report is submitted in draft to facilitate review of cost allocation studies included herein as Appendix D. Since allocation of cost will affect the views of local interests, it is desired to secure approval thereof before again requesting their views and submitting the report in final form.

3. In previous discussions, local interests have been informed that the cost of minimum provisions for future water supply must be a local contribution. Inasmuch as a future reapportionment will be required, even if the project is constructed in two stages, it is considered that the local interests should be allowed the interest free period and deferred payment provisions of the Water Supply Act of 1958, as amended. Accordingly, the cost of provisions for future water supply has been treated as a Federal cost, subject to future reapportionment when the second stage is constructed.

4. The project can be constructed as a multi-purpose project in one stage or in two stages. Single stage construction will cost

an estimated $1,380,000. Two stage construction will cost $1,026,000 for the first stage and $496,000 for the second stage, a total of $1,522,000. Based on 16 years between stages, the present worth of $496,000 is $309,000. Thus, the present worth of two stage construction is $1,026,000 + $309,000 or $1,335,000. As this is $45,000 less than the $1,380,000 for single stage construction it is concluded that the two stage construction is more economic unless the water is to be used in less than 16 years.

5. Consideration was given to the possibility that recreational use would provide additional benefits which might justify the additional cost of single stage construction. The project is located within a few miles of the Surry Mountain and Otter Brook Reservoirs, both of which are developed for recreation. Otter Brook is fully developed. The full potential of the Surry Mountain Reservoir has not been approached and additional users can readily be accommodated. It is considered that development of Beaver Brook for recreation will reduce the utilization of Surry Mountain and that the net benefits would be nominal, accordingly recreation is not included.

P. C. HYZER
Brigadier General, USA
Division Engineer

Incl(10 cys)
Draft

FLOOD CONTROL PROJECT

BEAVER BROOK

KEENE, NEW HAMPSHIRE

CONNECTICUT RIVER BASIN

NEW HAMPSHIRE

SUPPLEMENTARY RECONNAISSANCE REPORT

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CORPS OF ENGINEERS
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WALTHAM, MASS.

FLOOD CONTROL PROJECT

BEAVER BROOK

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CONNECTICUT RIVER BASIN
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SUPPLEMENTARY RECONNAISSANCE REPORT

March 1964

A. INTRODUCTION

1. PURPOSE. - The purpose of this report is to furnish additional information to supplement that contained in the Reconnaissance Report on Beaver Brook, Keene, New Hampshire, dated 20 March 1963. The information presented herein is based on studies made initially for the Survey Report authorized by the resolution of the Senate Committee on Public Works adopted 3 October 1960.

2. AUTHORIZATION. - This report is submitted pursuant to 1st Indorsement dated 20 August 1963, Subject: Reconnaissance Report Beaver Brook, Keene, New Hampshire.

B. DESCRIPTION

3. LOCATION AND EXTENT. - Beaver Brook, with a drainage area of about 10 square miles, is a small tributary of the Ashuelot River, which is in turn a part of the Connecticut River Basin. The brook flows southward through Keene, New Hampshire and joins another tributary called the Branch, which then discharges within a few hundred feet into the Ashuelot River. Beaver Brook drains parts of Keene and Gilsum and a small part of Sullivan, New Hampshire. Bingham Hill State Forest lies partly within the northern extremity of the watershed.

4. DRAINAGE AREA. - The Beaver Brook watershed area is rolling and hilly. From the new Route 9 highway crossing of the brook southward to Keene, the stream descends fairly rapidly through a narrow part of the valley where the topography does not favor the construction of a flood control dam. Just above the Route 9

crossing there is a good potential dam site. Above this point the valley widens somewhat and becomes open, containing a small pond and flat marshy areas. The hillsides are wooded, with medium sized trees mixed with smaller trees and brush. Elevations range from 776 feet above mean sea level, at the potential dam site, to almost 1600 feet on the top of Spaulding Hill in the northeast corner of the watershed, a difference of about 815 feet. Except for Spaulding Hill, the western slopes of the drainage area are, in general, steeper than the eastern slopes. The area is sparsely settled.

5. GEOLOGY. - The valley of Beaver Brook is physiographically located within the New England Upland in a maturely dissected region of moderately high relief. Glaciation has modified the pre-glacial bedrock topography by erosion, and to a greater extent by dumped and outwashed deposition of glacial debris from moving and stagnant ice masses. Glacial till, a heterogeneous product of direct deposition, generally blankets the bedrock surface and occasionally in the area has been molded into low hill features known as drumlins. The east-west valley of the Ashuelot River to the north was dammed by glacial till masses creating a temporary glacial lake which may have spilled over the present divide into the north-south valley of Beaver Brook. The till in the lower sides of the valley of Beaver Brook is overlain by remnants of gravelly terraces which were built by melt-water streams flowing beside tongues of ice.

The bedrocks of the region are principally Devonian in age and largely consist of granite and gneiss. Mica schist of the Littleton Formation narrowly fingers between these rocks along the valley of Beaver Brook and this zone of rock contacts may account for a largely structural origin of the valley.

6. STREAM CHARACTERISTICS. - Beaver Brook is formed by the confluence of several small branches flowing from Bingham Hill State Forest and the eastern slopes of Webster Hill, in the township of Gilsum, and the southwestern slopes of Spaulding Hill, in Sullivan and Gilsum. The headwaters rise at elevations ranging up to nearly 1600 feet (above mean sea level). The valley floor in the reservoir area slopes from elevation 880 at the upper or north end, to elevation 775 at the southern end. The brook then drops more rapidly to the flood plain in Keene, through which it flows for about two miles before joining the Branch and the Ashuelot River on the southern outskirts of the City, at an elevation of about 460 feet above mean sea level.

7. AREA MAPS. - Beaver Brook and its watershed are shown on standard quadrangle sheets of the U. S. Geological Survey (Scale 1:62,500). A map of the Beaver Brook watershed was included as Inclosure 1 of the Reconnaissance Report.

C. HYDROLOGY AND HYDRAULIC DATA

8. DRAINAGE AREA. - The total drainage area of Beaver Brook at the mouth is 10 square miles. The proposed reservoir would control a drainage area of 6 square miles.

9. ANALYSIS OF FLOODS. - Although there are no gaging stations on Beaver Brook, there are six located within the Ashuelot River Basin with drainage areas ranging from 36 to 420 square miles, including two just below the existing Surry Mountain and Otter Brook Dams. On the Ashuelot River there are also staff gages at Swanzey and West Swanzey and a non-recording telemark near the mouth of the Branch.

The availability of flood data at these points and data from studies for the existing reservoirs made possible the development of rating curves on Beaver Brook, taking into account the backwater effect from the Ashuelot River. Discharge frequency curves were developed for the Ashuelot River at West Swanzey and for Beaver Brook in accordance with procedures published in ER 1110-2-1450. For Beaver Brook, frequency data was derived from correlations with gaging station records from the South Branch and Otter Brook.

10. STORAGE CAPACITY. - Prior to 1955, it was considered that there should be sufficient storage capacity in a flood control reservoir to hold six inches of runoff from the watershed upstream of the project. The volume of runoff experienced in the major floods of 1955 has demonstrated that it is desirable to provide at least 8 inches with up to 10 inches for smaller drainage areas whenever feasible. Therefore it is proposed that Beaver Brook Reservoir have a storage capacity of 10 inches of runoff, equivalent to about 3200 acre feet. A spillway crest elevation of 810 feet m.s.l. would provide this capacity. In the case of a multi-purpose reservoir, a spillway crest elevation of 820 feet, m.s.l. would be indicated.

11. SPILLWAY DESIGN FLOOD. - Values of rainfall for the spillway design flood were obtained from Hydrometeorological Report No. 33, dated April 1956, as prepared by the U. S. Weather Bureau. The adopted storm for the derivation of the flood was selected as 100 percent of the all-season probable maximum precipitation for 50 square miles. Losses from infiltration, surface detention and transpiration were

assumed at a rate of 0.05 inches per hour. The rainfall for 24 hours was computed at 23.2 inches, with a resulting excess of 22.0 inches. The 2-hour adopted unit hydrograph, comparable to those for areas similar in size and characteristics, has a peak of 850 c.f.s. The spillway design flood derived from these criteria has a peak inflow of 8,800 c.f.s., equivalent to about 1,465 c.s.m. The flood was routed through the reservoir, assuming the reservoir initially full to spillway crest and disregarding outlet discharge, using a chute ogee spillway with a length of 55 feet. The resulting discharge peak from the flood control reservoir would be 5,500 c.f.s. with a maximum surcharge of 10 feet. In the case of the multi-purpose reservoir, the peak discharge would be 4,800 c.f.s., with a maximum surcharge of 8 feet. A freeboard of 5 feet was selected, resulting in top-of-dam elevations of 825 feet, m.s.l., for the flood control reservoir and 833 feet, m.s.l. for the multi-purpose reservoir.

12. EFFECT OF REGULATION. - The proposed reservoir on Beaver Brook would provide a high degree of protection from overbank flooding along Beaver Brook for its entire length as it flows through the City of Keene. In major floods, such as the September 1938 floods, the reservoir would cause a reduction in flows from about 75 percent in the upper reaches to about 55 percent in the lower reaches. In moderate floods, such as the April 1960 flood, the flows would be reduced by about 65 percent in the upper reaches and by about 45 percent in the lower reaches.

13. RESERVOIR OUTLET CAPACITY. - The outlet for the Beaver Brook Reservoir would consist of a single ungated conduit with a capacity of 120 c.f.s. A circular conduit was selected with diameters of 30 inches for the flood control reservoir and 27 inches for the multi-purpose reservoir. The selected conduit would have the necessary capacity and would require a period of about 15 days in which to empty the full reservoir. A standard project flood developed according to established procedures, and the flood of record were routed through the reservoir. The storage and outlet capacities proved adequate.

D. EXTENT AND CHARACTER OF THE FLOODED AREA

14. GENERAL. - The City of Keene has been particularly susceptible to heavy flood losses throughout its history. The flat basin in which it lies was the bed of an ancient lake of the glacial era. The Ashuelot River flowing through the basin is joined just below Keene by several smaller tributaries, including Beaver Brook and Otter Brook, and by the South Branch further downstream. This

area forms a flood plain, with very poor natural drainage. In the major floods of 1936 and 1938, overflow and backup of these streams flooded large areas in Keene, causing substantial losses to industrial, residential and business properties. Surry Mountain Dam on the Ashuelot and Otter Brook Dam on Otter Brook have substantially reduced flood stages on the Ashuelot, and the authorized Honey Hill Dam on the South Branch, if built, would furnish additional control. Still vulnerable, however, is the thickly settled area along the banks of Beaver Brook which flows through the heart of Keene.

15. BEAVER BROOK FLOOD PLAIN. - Of the 42 industrial firms in Keene, approximately half are located within the flood plain of Beaver Brook. These 20 odd plants in the Beaver Brook area employ 1,560 persons with an annual payroll of $6,750,000. In the April 1960 flood, some 60 acres of the Beaver Brook flood plain were inundated to varying depths. Residential areas east of the business district were cut off from access by wheeled vehicles, and boats were used in the streets. Storm and sanitary sewers backed up, causing nuisance flooding in streets and yards above the high water level. The April 1960 flood resulted in the formation of the Beaver Brook Association, whose petition to the City Council for relief from the flood problem resulted in this survey and report.

E. FLOOD DAMAGES

16. FLOOD DAMAGES. -

a. Flood of September 1938. - The record flood of September 1938 caused damages in the Ashuelot River Basin amounting to $1,138,000. Approximately 45 percent of this loss was sustained within the city limits of Keene, New Hampshire. The heaviest losses occurred in the densely populated areas along the banks of the Ashuelot River and Beaver Brook. Some 372 properties, including 347 homes, 15 commercial firms and 10 industrial plants, experienced losses along Beaver Brook amounting to $218,000.

b. Flood of April 1960. - The flood of April 1960 caused damages estimated at $100,000 in Keene. Eleven industrial firms, seven commercial establishments and about 250 residences housing approximately 400 families were affected by flooding of grounds and cellars. The estimated damages do not include municipal costs such as cleaning up debris in the flooded area, or providing emergency facilities.

17. RECURRING LOSSES. - Under conditions existing in 1963, it is estimated that a recurrence of 1938 flood stages in the Ashuelot

River Basin would cause losses amounting to $5,190,000. Nearly $3,660,000 of this amount would be experienced in the City of Keene and would be distributed as follows: $2,970,000 along Beaver Brook and the remainder on the Ashuelot River. Even with the operation of the existing projects at Surry Mountain and Otter Brook, losses amounting to $1,785,000 would be experienced within the flood plain of Beaver Brook. Adding the authorized Honey Hill Dam to the system would reduce this loss to $1,195,000. Tables A-II and A-III in Appendix A show recurring and preventable losses by existing, authorized and recommended projects.

18. AVERAGE ANNUAL LOSSES. - Estimated recurring losses were converted to average annual losses as a basis for determining average annual benefits for use in economic evaluation of the studied project. The average annual loss in the Ashuelot River Basin in the reaches below Beaver Brook Dam is $438,000 without flood protection. Of this loss, $195,800 occurs on Beaver Brook and the remainder on the Ashuelot River below Surry Mountain in Keene. Operation of the existing Surry Mountain and Otter Brook Dams will reduce annual losses on Beaver Brook to $89,300 and losses on the Ashuelot River zones to $96,700, resulting in a total annual loss of $186,000 under present conditions. The estimate of annual losses has been derived in accordance with Corps of Engineers practice of correlating stage-damage, stage-discharge, discharge-frequency, and damage-frequency relationships.

Appendix A contains detailed descriptions of damage surveys, loss summaries, and annual losses and benefits.

19. TRENDS OF DEVELOPMENT. - Keene, New Hampshire, has shown a steady economic growth for the past thirty years. Trends, established by review of statistics such as value of manufacture added, retail sales, and population, and availability of land within the flood plain indicate that flood losses will grow at the rate of 1.5 percent per year for the next 20 years, before available lands are fully utilized. On an equivalent basis, annual benefits for growth over the life of the project would amount to $17,700 ($14,400 in the alternate system). Inasmuch as project construction is not expected to materially hasten this growth, no enhancement benefits have been evaluated. Data on economic trends in Keene are set forth in Appendix A.

F. EXISTING AND AUTHORIZED FLOOD CONTROL PROJECTS

20. CORPS OF ENGINEERS' PROJECTS. - There are no existing Corps of Engineers flood control projects in the Beaver Brook watershed. Completed and recommended flood control projects in the Ashuelot

River Basin which affect flood stages in the downstream portion of the basin are discussed below.

21. COMPLETED PROJECTS IN THE KEENE AREA. -

a. Surry Mountain Dam and Reservoir. - Surry Mountain Dam, authorized by the Flood Control Act, approved 28 June 1938 (Public Law 761, 75th Congress), is located on the Ashuelot River in the Town of Surry, about 4.5 miles north of Keene. The dam is a rolled fill earth embankment 1,670 feet long and 86 feet high, faced with dumped rock. At spillway crest, the reservoir has a length of about 3 miles. The reservoir capacity is 32,500 acre-feet, equivalent to 6.1 inches of runoff from the 100 square mile drainage area.

b. Otter Brook Dam and Reservoir. - Otter Brook Dam, authorized by the Flood Control Act, approved 3 September 1954 (Public Law 52, 83rd Congress), is located on Otter Brook on the boundary between the City of Keene and the Town of Roxbury. The Dam is approximately 2.2 miles east of the center of Keene. The dam is a rolled fill earth embankment 1,288 feet long and 133 feet high faced with dumped rock. At spillway crest, the reservoir has a length of about 2.3 miles. The reservoir capacity is 17,600 acre-feet, equivalent to 7 inches of rainfall from the 47 square miles of drainage area.

c. Snagging and Clearing Work on Ashuelot River. - Snagging and clearing work on the Ashuelot River from the railroad bridge in Keene to the covered bridge at Swanzey Station (22,800 feet) was authorized by the Chief of Engineers on 20 August 1953 in accordance with Section 13 of the Flood Control Act of 1946 (Public Law 526, 79th Congress). The project consisted of the removal and disposal of 50 snags and debris, 260 trees, 45,000 cubic yards of material in two cutoff channels, 20 clumps of trees, and the overhanging branches of 50 trees. The total length of the cutoff channels is 1,800 feet and they bypassed 5,600 feet of meandering river channel. This project improved flow conditions in the reach below Beaver Brook. The improvement of this channel shortened the period of high river stages, lowering the backwater elevations and thus reducing the duration and amount of flooding in the Keene flood plain.

22. AUTHORIZED PROJECTS. -

a. Honey Hill Dam and Reservoir. - Honey Hill Dam, authorized by the Flood Control Act, approved 18 August 1941 (House Document 724, 76th Congress, 3rd Session), would be located on the South Branch of the Ashuelot River 5.6 miles from the junction with the Ashuelot River and 1 mile west of East Swanzey. The proposed dam would be a rolled fill earth embankment 2,860 feet long and 65 feet high faced with dumped rock. At spillway crest the reservoir would have a length of 3 miles. The reservoir capacity would be 26,200 acre-feet, equivalent to 7 inches of runoff from the 70 square mile drainage area. Construction of this project has been held up by opposition on the part of local interests.

G. FLOOD PROBLEMS AND SOLUTIONS CONSIDERED

23. FLOOD PROBLEM AND RELATED PROBLEMS. - The Keene flood plain has very poor natural drainage. The Ashuelot River flowing through it is joined by a number of smaller streams in this flood plain, resulting in some ponding during most floods. Channel clearing operations and the Surry Mountain flood control dam on the Ashuelot River help to keep down the flood stages in that stream. The Otter Brook flood control dam controls a tributary of the Ashuelot. Keene's flood control problems are severe, however, and a number of tributaries remain uncontrolled. One of these is Beaver Brook, which flows through the heart of the city. Due to flat slopes in the city and high water from the uncontrolled tributaries entering the plain below Beaver Brook, backup occurs even in a minor flood and larger areas become inundated. Industrial and commercial establishments suffer heavy losses and cellars and streets in a thickly populated residential area are flooded. Storm drains become almost completely inoperative and clogged, and a health hazard results from backup of the sanitary sewers. Raw sewage is discharged into the streets when the covers are forced off manholes. The city's one producing water supply well has also been flooded, and high municipal costs have resulted from cleanup operations. Fortunately, no epidemic has yet occurred during such conditions, but the danger is a matter of concern to all residents of the city.

24. SOLUTIONS CONSIDERED. -

a. Local Protection of High Damage Areas. - Preliminary studies of this measure quickly demonstrated that the local protection of small areas was extremely impracticable as an alternative to a flood control dam. Local protection measures for flood control would involve widening and channel improvement of the brook all the way through the city, described below.

b. Channel Improvement of Beaver Brook. - Preliminary estimates of annual benefits of this means of protection are about 60% of those for a reservoir project. The cost of such measures, including channel excavation, flood walls, riprap, drainage modifications, and the replacing of some 14 bridges, would be well in excess of that for a flood control dam. It would also result in a major disruption of traffic while the bridges were being replaced. There would be no downstream benefits from such a plan.

c. Diversion of Beaver Brook. - Diversion of flood flows from Beaver Brook westerly into the Ashuelot River or easterly into Otter Brook Reservoir would be possible. Either of these diversions would be more costly than the recommended plan. A westerly diversion would not be practicable as the increased flows in the Ashuelot River would exceed the channel capacity through this part of the City and, in addition, would not reduce the effect of Ashuelot River backwater. An easterly diversion would reduce the effectiveness of the Otter Brook Reservoir.

d. Modification of the Dam at West Swanzey. - Hydraulic analysis reveals that modification of the dam at West Swanzey would have little effect on the flood stages in the Keene flood plain, since the dam becomes a drowned-out weir in major floods. The hydraulic gradient of the Ashuelot is flat for a considerable distance below Keene. Removal of the dam would help somewhat, but would not constitute a solution to the Beaver Brook flood problem.

e. Channel Improvement of the Ashuelot River. - This is the one single measure that might come closest to solving the flood problem of Keene, by lowering the channel in the Ashuelot River so that a high rate of drainage and discharge could occur from all the tributaries emptying into the Keene flood plain. This plan would have no downstream benefits whatever, -indeed, it would increase Ashuelot River discharges and cause more losses along the Connecticut River. It would also be enormously expensive, for it would involve deepening the channel bed of the Ashuelot from Keene more than 20 miles downstream.

f. Flood Control Dam on Beaver Brook. - For this measure the costs are the least and the benefits are at a maximum. This gives the highest measure of control, which is an advantage to the low-lying homes and business installations along Beaver Brook. Direct control of flood flows in the brook would mean that flood levels in the upper reaches of the flood plain would be drastically reduced, and also that the hydraulic gradients of the storm drains and sanitary sewers in the area would be improved. Direct benefits would accrue to the Keene area and the Ashuelot Valley. Another factor of major importance is that a flood control dam and reservoir on Beaver Brook makes possible a multi-purpose use. Water supply storage is an important consideration. If later examination shows that other sources of water supply may be more economical, local recreational development and fish and wildlife development at Beaver Brook Dam would then assume a larger importance.

25. RELATED WATER RESOURCE CONSIDERATIONS. -

a. Hydraulic Power. - In view of the small volume of normal flow, hydraulic power is not considered practicable for Beaver Brook Dam and Reservoir.

b. Water Supply. - The consulting firm of Camp, Dresser and McKee, making a study of water supply needs and potential sources for Keene, estimates that by the year 1980, the average demand will have reached 4.5 mgd (million gallons per day), or 1.0 mgd in excess of the safe yield of the present system. The peak demand in 1980 is estimated at 7.2 mgd, or 2.7 mgd in excess of the maximum capacity of the present system. The U.S. Department of Health, Education and Welfare in a letter dated April 17, 1962 points out that while the safe yield of the existing Keene system is 3.5 mgd, preliminary estimates indicate that the demand for water will increase on the average from about 2.6 mgd to 6 mgd within the next fifty years. Therefore, development of an additional source of supply with a safe yield of at least 4.0 mgd appears desirable. Water supply considerations affecting the project formulation are discussed further in Appendix B.

c. Low Flow Augmentation. - The U.S. Department of Health, Education and Welfare has considered the need for low flow augmentation for water quality control in Beaver Brook, and conferred with interested agencies of the State of New Hampshire on the subject. The tentative conclusion of the Department, in a status report of April 17, 1962 on its study of water resource needs for Keene, is that low flow augmentation is not necessary.

d. Fish and Wildlife Development. - The U.S. Fish and Wildlife Service has indicated interest in the development of Beaver Brook Reservoir as a wildfowl nesting area. It is recognized, however, that the fluctuations in level of a water supply pool would not be compatible with this use. If water supply storage is not considered to be desirable, however, a low permanent pool for wildfowl could be maintained without materially impairing the flood control storage capacity.

e. Recreation. - In view of the accessibility of Surry Mountain and Otter Brook Reservoirs to Keene, both developed for recreation, it was considered that a permanent pool for recreational purposes would not be justified at Beaver Brook. The Acting Regional

Director of the National Park Service after discussion with the Director of the New Hampshire Recreation Division, concurred with this determination. There would therefore be little or no associated recreational development to justify the acquiring of marginal areas as recommended in the Engineering Manual (EM 405-2-150, REAL ESTATE, paragraph 9a), as a requirement of local cooperation.

H. FLOOD CONTROL PLANS

26. GENERAL. - Studies indicate that flood control for the Beaver Brook flood plain in Keene, New Hampshire is needed and is feasible. Protection by alternative methods was considered in the studies. Due to the characteristics of the area, complete protection for the lower part of the Beaver Brook flood plain could not be obtained by any solution within the scope of this report, since there would be some backup into Beaver Brook from uncontrolled discharges emptying into the Keene flood plain. The flood control dam, however, would furnish substantial protection from overbank flooding to the homes and commercial and industrial installations along Beaver Brook.

27. RECOMMENDED PLAN. -

a. Description of Site. - The Beaver Brook site is located on Beaver Brook about 1100 feet north of the new Route 9 crossing of the brook. The dam site is relatively narrow, with exposed rock surface near the river and at various locations high up and beyond the abutments. The bedrock is mainly schist with some pegmatite in the west abutment. Geological and topographical conditions are suitable for the construction of the proposed dam. The stream valley broadens into a relatively large basin suitable for storage of a large quantity of water with a relatively low dam. Flowage costs for the reservoir would be low, as there are relatively few improvements in the area. The State of New Hampshire plans to reconstruct existing Route 10 through the valley and has held up further planning pending development of this project. The relocation can be accomplished at moderate expense by reconstructing the highway at a higher elevation than originally planned.

b. Description of Dam and Reservoir. - Inclosure 3 of the Reconnaissance Report is a general plan of the proposed Beaver Brook flood control project. The dam would be of rolled earth fill construction with rock slope protection and with a concrete chute-type spillway. The capacity of the flood control pool would be 3200 acre-feet, equivalent to 10 inches of runoff from the drainage area of 6 square miles at spillway crest elevation of 810 feet, m.s.l. The reservoir would include an area of 230 acres which is mostly woodland and waste land. A group of maintenance buildings owned by the New Hampshire Department of Public Works and Highways and less than 10 rural residences would be affected.

c. Spillway Design Flood. - The estimated spillway design flood inflow into the reservoir and the peak discharge of the spillway design flood would be 8,800 c.f.s. and 5,500 c.f.s., respectively. The design flood inflow would be equivalent to 1,465 c.f.s. per square mile from the gross tributary drainage area. The design discharge of 5,500 c.f.s. would produce a surcharge of 10 feet for a spillway 55 feet long. It is proposed to use a freeboard of 5 feet, which would bring the top of the dam to elevation 825.0 m.s.l., 15 feet above spillway crest.

d. Outlet. - The outlet would consist of a 5 foot by 5 foot reinforced cast-in-place rectangular concrete conduit founded on glacial till. The conduit would be gated in the intake structure or throttled by means of an orifice. The pool elevation would be adjustable between elevations 786 and 790 by means of stoplogs.

e. Provisions for Future Raising. - Provision for future raising would be included in the construction of the dam. The conduit would be designed for the future embankment height and would extend downstream so that no further extension would be necessary when the dam is raised later. The intake structure would be placed on a concrete base resting on bedrock to support a future intake tower. The spillway crest would be pierced by a flood control outlet with provisions for a future weir, adapted to multi-purpose use.

f. Changes in Utilities. - The most important relocation in the reservoir area would be 3 miles of Route 10, a State-aid highway. The final alignment of the relocated road would be determined through agreement with the State of New Hampshire. The City of Keene and the State would cooperate in providing funds for the relocation above the reservoir level. Telephone and electric power lines along Route 10 would also be relocated.

28. FIRST COSTS. - Unit prices used in estimating construction costs are based on average bid prices for similar work in the same general region, with adjustments made for topography, distances to source of materials, and other local factors. Valuations of property are based on information from local officials and reflect values in recent sales in the area. All costs include an allowance for contingencies and for minor items of work which do not appear in the estimate. The estimated costs for engineering and overhead are based

on knowledge of the site and experience on similar projects. A summary of first costs for the recommended plan is given in Table I below. A detailed breakdown of the costs of the plan is given in Appendix B. Estimates of costs of a single purpose plan for flood control and a single stage multi-purpose plan for flood control and water supply are given in Appendix C.

TABLE I

FIRST COSTS

Item	Amount	Total
Direct Costs		
Lands and Damages	$180,000 (1)	
Relocations	226,000 (2)	
Reservoir Clearing	5,000	
Dam	403,000 (3)	
Miscellaneous Structures, Equipment, etc.	62,000	
TOTAL DIRECT FIRST COST		$876,000
Indirect Costs		
Engineering and Design	$105,000	
Supervision and Administration	45,000	
TOTAL INDIRECT COSTS		$150,000
TOTAL PROJECT FIRST COST		$1,026,000 (4)

(1) Includes $40,000 for extra lands to be purchased by local interests for possible future multi-purpose use of reservoir.

(2) Includes $66,000 for costs of relocations of highway to grade suitable for future multi-purpose use of reservoir.

(3) Includes $25,000 for minimum provisions for future raising of dam.

(4) Includes $131,000 for minimum provisions for future multi-purpose use of reservoir.

29. ANNUAL CHARGES. - Average annual costs, summarized in Table II are based on interest rates of 3 percent for both Federal and Non-Federal costs. Investment costs are amortized over the 50-year assumed life of the project. It is assumed that the second stage construction will take place 16 years after the first stage. The $496,000 estimated cost of the second stage construction is converted to present value and then amortized over the 50-year life of the project. Allowances are made for maintenance and operation and for interim replacement of equipment. These allowances are averaged over the 50-year project life. Allowance has been made for loss of taxes on land in Gilsum, but not in Keene as it is considered that these latter losses would be more than offset by the increases in value of the properties with flood protection. Allocation of average annual costs is developed in Appendix D, Allocated annual costs for flood control are $35,190.

TABLE II

ANNUAL CHARGES

Item		Amount
Interest (.03x$1,026,000)		$30,780
(.03x.6232x$496,000)		9,270
Amortization (.00887x$1,026,000)		9,100
(.00887x.6232x$496,000)		2,740
Maintenance and Operation		
First 16 years (3000x12.561x.03887 = 1460)		
Last 34 years (6000x21.132x.03887 = 3070)		
	TOTAL	4,530
Major Replacements		
First 16 years (450 x12.561x.03887 = 220)		
Last 34 years (1400x21.132x.6232x.03887 = 720)		
	TOTAL	940
Loss of Taxes on Land		
First 16 years (1440x12.561x.03887 = 700		
Last 34 years (1600x21.132x.6232x.03887 = 820		
	TOTAL	1,520
	TOTAL ANNUAL CHARGES	$58,880

I. ANNUAL BENEFITS

30. AVERAGE ANNUAL BENEFITS. - The operation of Beaver Brook Dam and Reservoir would reduce flood damages along Beaver Brook and the Ashuelot River downstream of Keene. Annual benefits were derived along Beaver Brook by evaluating the difference in annual losses without flood protection and those remaining after project completion. On the lower reaches of Beaver Brook affected by backwater and on the Ashuelot River, annual benefits were computed for Beaver Brook Dam acting (1) next after the existing Surry Mountain and Otter Brook Dams and (2) next after the completed reservoirs and Honey Hill Dam on the South Branch (authorized but not built). Average annual benefits attributable to the Beaver Brook Project adjusted for the growth projected to occur over the next 20 years amount to $102,200, acting next after the existing Surry Mountain and Otter Brook Dams. In the alternate system, Beaver Brook acting next after Surry Mountain, Otter Brook, and authorized Honey Hill Dam, annual benefits amount to $83,500.

31. INTANGIBLE BENEFITS. - Although intangible benefits of Beaver Brook might be of considerable magnitude, none have been evaluated for the purpose of this report. Letters from about 60 members of the Beaver Brook Association submitted at the Public Hearing were consistent in describing the extremely unsanitary conditions, the inconveniences and the interruption of facilities associated with flooding in the Beaver Brook area. The presidents of three local banks referred to the evidences of progressive blight. Such conditions put increasing loads on the community, the costs of which are difficult to assess. The tangible evidences of health and economic growth spring from the intangible factors of confidence and optimism. These would be among the results of a dam and reservoir on Beaver Brook.

J. PROJECT FORMULATION AND ECONOMIC JUSTIFICATION

32. BENEFIT-COST RATIO. - The annual flood control benefits for the dam are estimated at $102,200. Annual costs for the flood control features of the dam are estimated at $35,190. This sum does not include the annual charges for extra lands, damages and relocations, since these charges are extras and completely the responsibility of local interests. Likewise, the cost of minimum provisions for future raising and joint use costs for future water supply are excluded. The benefit-cost ratio of the flood control project is therefore 2.9 to 1. If the authorized Honey Hill Dam were built

first, annual flood control benefits for Beaver Brook Dam would be decreased to $83,500. This would result in a benefit-cost ratio of 2.4 to 1.

33. APPORTIONMENT OF COST AMONG INTERESTS. - Local interests are required to contribute toward the cost of the project, since the benefits are predominantly within the boundaries of the community. Local interests are required to pay for all lands, relocations and rights-of-way as well as the water supply costs. Water supply costs include the cost of making the conduit longer and stronger as well as an equitable share of the joint use costs of the first stage construction. Table D-V in Appendix D, summarizes the allocation of costs between Federal and Non-Federal interests. Cost allocations are developed in Appendix D of this report.

K. PROPOSED LOCAL COOPERATION

34. PROPOSED LOCAL COOPERATION. - In accordance with Section 3 of the 1936 Flood Control Act, as amended, local interests would be required to provide, without cost to the United States, all lands, easements, and rights-of-way necessary for the construction and operation of the local protection project; hold and save the United States free from damages due to the construction works; and maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army.

Acquisition of lands required for spoil disposal and borrow areas, as well as for relocation of a stretch of New Hampshire Route 10 and any local roads affected, would also be the responsibility of local interests.

Local interests would also be required to provide assurances that encroachments in the channel and on ponding areas would not be permitted and that, if ponding areas and/or capacities are imparied, substitute storage capacity will be provided promptly without cost to the United States. In order to qualify for the Corps of Engineers Program for Construction of Small Projects for Flood Control and Related Purposes under the Authority of Section 205 of Public Law 87-874, local interests would also be required to assume full responsibility for all project costs in excess of the Federal cost limitation of $1,000,000 and found necessary to provide a complete project, and to make cash contribution for project costs allocated to project features other than flood control.

Under provisions of the Water Supply Act of 1958, as amended, local interests would also be required to pay the separable or incremental costs of the water supply function and, in addition, contribute to the joint costs on the basis that all authorized purposes served by the project shall share equitably in the benefits of multiple-purpose construction. Reimbursement of such costs will be required under the provisions of the Water Supply Act. As shown in Appendix D, the incremental costs of construction are presently estimated at $25,000 and the equitable share of the joint costs is estimated at $63,000. Further assurances of local cooperation to provide for these reimbursements will be requested.

There is a strong desire for additional flood protection in Keene. State and city officials have indicated a willingness and ability to fulfill the conditions of local cooperation. Under recent legislation, the State of New Hampshire has appropriated $150,000 to be applied to the costs of lands and relocations.

L. PUBLIC HEARINGS

35. PUBLIC HEARINGS. - A public hearing was held on 7 February 1962. Strong support for a flood control project on Beaver Brook was expressed by many individuals and various interests. No opposition to the reservoir plan was indicated by anyone.

Adequate press coverage was provided prior to the hearing and has been continued. There has been no hint of any opposition to the project. No further public hearing is considered necessary at this time.

Arrangements will be made to afford interested parties an opportunity to obtain information or to object at a meeting of the Keene City Council. This will avoid the necessity for repetition of the lengthy presentation of expressions of opinion and supporting information in favor of the project.

M. COST OF REPORT

36. COSTS FOR PREPARATION OF DETAILED PROJECT REPORT. - The figure of $105,000 requested in the Reconnaissance Report was intended to include preparation of plans and specifications. A revised estimate of cost for preparation of the Detailed Project Report only will be included when this report is submitted in final form.

N. RECOMMENDATION

37. RECOMMENDATION. - Recommendation will be included when this report is submitted in final form.

APPENDIX A

FLOOD LOSSES AND BENEFITS

APPENDIX A

FLOOD LOSSES AND BENEFITS

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TABLES

PLATES

APPENDIX A

FLOOD LOSSES AND BENEFITS

1. DAMAGE SURVEYS. - Damage surveys were conducted throughout the Ashuelot River Basin immediately after the September 1938 flood. Data obtained from the survey were later supplemented by reviews in 1947 and 1953. These reviews were undertaken to check the change and extent of development within the flood plain since the initial 1938 study. The latest survey, made immediately after the April 1960 flood, was confined to the flood area along Beaver Brook in the City of Keene. In view of the higher stages previously experienced during the September 1938 flood, estimates of recurring losses were obtained for both the 1938 and 1960 flood crests.

Essentially, the damage surveys comprised door-to-door inspections and interviews of the several hundred residential, commercial, industrial and other properties affected by flooding. The recorded information included the extent of the areas flooded, descriptions of properties, nature and amount of damage, depth of flooding, high-water references and relationships to prior flood stages. Estimated evaluations of damages were generally furnished by property owners. Investigators applied their own judgement in modifying owner or tenant estimates deemed to be unrealistic and developed estimates when owner or tenants were not available. Sampling methods were used where properties of the same general type were subject to the same depth of flooding.

In the latest survey, sufficient data were obtained to determine the stage at which damage begins and to derive losses for: (1) the 1960 and 1938 flood crests; (2) stages 1 to 2 feet higher than the 1938 flood; and (3) intermediate stages where sharp changes in damage occurred.

2. LOSS CLASSIFICATION. - Flood loss information was recorded by type of loss and location. Loss types used were industrial; urban, comprising commercial, residential, and public; rural; highway; and railroad. Losses evaluated included (1) physical losses, such as damage to structures, machinery and stock, and the cost of cleanup and repairs, and (2) non-physical losses, such as unrecoverable loss of business and wages, cost of temporary facilities and increased cost of operation.

The losses resulting from physical damages and a large part of the related non-physical losses were determined by direct inspection of property and evaluation of losses by the property owners and/or field investigators. Where non-physical portions of losses could not be determined from available data, estimates were based upon the relationship between physical and non-physical losses for similar properties in the area. No evaluations were made of intangible damages including such items as loss of life, hazards to public health and impairment of national security.

3. FLOOD DAMAGES. - The record flood of September 1938 resulted in an estimated loss of nearly $1,138,000 in the Ashuelot River Basin. Over 1,200 families were forced from their homes, and 150 commercial and industrial properties were badly damaged. Keene, New Hampshire, the largest community in the watershed, was the principal center of damage, sustaining losses amounting to about $515,000. Of this amount, $218,000 was encountered along Beaver Brook, where flood stages reached as high as 5 feet over first floor levels. Some 372 properties were affected, including 347 homes, 15 commercial firms and 10 industrial plants.

Downstream of Keene, business, residential, and rural areas in the Towns of Swanzey, Winchester, and Hinsdale were also flooded. On the minor tributaries and near the headwaters, damage was principally to highways and railroads. Highway losses accounted for more than 28 percent of the total damage. Table A-I shows the 1938 experienced flood losses in the Ashuelot River Basin, by town and type of loss.

The most recent flood to strike Keene occurred in April 1960, when Beaver Brook overtopped its banks. Some 267 properties sustained losses amounting to nearly $100,000. Included in this loss were some 249 homes, 11 industrial firms, and 7 commercial establishments. Operation of the existing Surry Mountain and Otter Brook flood control dams prevented additional losses along the Ashuelot River and its tributaries.

TABLE A-I

Experienced September 1938 Flood Losses

Ashuelot River Basin

(Losses in $1,000 Units)

Town	Urban	Industrial	Rural	Highway	Railroad	Total
Hinsdale	$ 900	$ 12,500	$ -	$ 14,200	$ 2,400	$ 30,000
Keene	163,200	227,900	25,800	56,000	42,000	514,900
Marlboro	8,700	27,900	1,400	75,400	-	113,400
Swanzey	3,100	38,500	18,100	20,400	8,000	88,100
Winchester	75,600	131,800	20,600	33,200	8,000	269,200
Other Towns on tributaries unaffected by projects	-	-	-	118,200	4,200	122,400
	$251,500	$438,600	$65,900	$317,400	$64,600	$1,138,000

4. <u>RECURRING AND PREVENTABLE LOSSES</u>. - A recurrence of September 1938 flood stages in the Ashuelot River Basin under present conditions would cause an estimated loss of $5,190,000 without flood protection. More than 70 percent of this amount would be experienced within the city limits of Keene. Damages along Beaver Brook would amount to $2,970,000, representing more than 57 percent of the total basin loss. Operation of the existing flood control dams at Surry Mountain and Otter Brook would reduce damages from $5,190,000 to $2,935,000. Of this residual loss, $1,620,000 would be eliminated with the construction of the recommended Beaver Brook Dam and Reservoir. In the alternate system, the authorized Honey Hill Dam in conjunction with the existing dams at Surry Mountain and Otter Brook would reduce losses from $5,190,000 to $2,070,000. Adding Beaver Brook Dam and Reservoir to the system would provide additional savings of $1,180,000. Tables A-II and A-III show recurring September 1938 losses without flood protection and losses preventable by the existing, authorized and recommended flood control dams.

TABLE A-II

Flood of September 1938 - Ashuelot River Basin

Description of Damage Reaches - Recurring and Preventable Losses

(1963 Price Level)

Reach Description	Recurring Losses	Losses Preventable by existing Surry Mountain and Otter Brook Dams	Losses Preventable by recommended Beaver Brook Dam after Surry Mountain and Otter Brook Dams	Losses Preventable by authorized Honey Hill Dam after Surry Mountain, Otter Brook and Beaver Brook Dams	Residual Loss
Beaver Brook - Beaver Brook Dam site to mouth	$2,970,000	$1,185,000	$1,575,000	$125,000	$ 85,000
Ashuelot River - Surry Mountain Dam to mouth of South Branch River	690,000	585,000	15,000	75,000	15,000
Ashuelot River - Mouth of South Branch River to mouth of Wheelock Brook	120,000	75,000	5,000	40,000	-
Ashuelot River - Mouth of Wheelock Brook to mouth of Ashuelot River	620,000	410,000	25,000	185,000	-
Tributaries	790,000	-	-	-	790,000
TOTAL	$5,190,000	$2,255,000	$1,620,000	$425,000	$890,000

TABLE A-III

Flood of September 1938 - Ashuelot River Basin

Description of Damage Reaches - Recurring and Preventable Losses

(1963 Price Level)

Reach Description	Recurring Losses	Losses Preventable by existing Surry Mountain and Otter Brook Dams	Additional Losses Preventable by authorized Honey Hill Dam	Losses Preventable by Beaver Brook Dam after Surry Mountain Otter Brook and Honey Hill Dams	Residual Loss
Beaver Brook - Beaver Brook Dam site to mouth	$2,970,000	$1,185,000	$590,000	$1,110,000	$ 85,000
Ashuelot River - Surry Mountain Dam to mouth of South Branch River	690,000	585,000	90,000	-	15,000
Ashuelot River - Mouth of South Branch River to mouth of Wheelock Brook	120,000	75,000	45,000	-	-
Ashuelot River - Mouth of Wheelock Brook to mouth of Ashuelot River	620,000	410,000	140,000	70,000	-
Tributaries	790,000	-	-	-	790,000
TOTAL	$5,190,000	$2,255,000	$865,000	$1,180,000	$890,000

5. AVERAGE ANNUAL LOSSES. - Annual losses were derived for the reaches downstream of the proposed Beaver Brook Dam site by utilizing stage-damage, stage-discharge and discharge-frequency data to develop damage-frequency curves. The area under these curves, which have been plotted with damage as the ordinate and with percent-chance-of-occurrence as the abscissa, is a measure of the average annual loss.

The average annual loss in the reaches below the proposed Beaver Brook Dam site in the Ashuelot River Basin totals $438,300 without flood protection. Of this loss, $195,800 occurs on Beaver Brook and $242,500 on the damage zones of the Ashuelot River downstream of the Surry Mountain and Otter Brook Dams. Operation of these dams which have been constructed will reduce annual losses on Beaver Brook to $89,300 and losses on the Ashuelot River zones to $96,700, resulting in a total modified annual loss of $186,000.

6. TRENDS OF DEVELOPMENT. - Keene has been a commercial and industrial center for Cheshire County and the western portion of the center of New Hampshire for many years. Review of statistics for manufactures, retail trade, and population reveal that the City of Keene has followed the county and the State in a steady economic growth over the past three decades which is exceeded only by the rates of growth of the Gross National Product and the national population. Table A-IV includes pertinent data as to growth paremeters. The older industries have held their own or been replaced by new enterprises. The machine tool and wood products industries have expanded and electronics and plastic plants have moved into the area. Commercial establishments have participated in this growth. The flood plain along Beaver Brook and its confluence with the Ashuelot River has been the site of construction of several industrial establishments in the past twenty years. Availability of land in the flood plain, together with trends exhibited, lead to the conclusion that flood losses will grow at the rate of 1.5 percent per year for the next twenty years before the available lands are fully utilized. Conversion of this growth to an annual equivalent basis over the project life of 50 years results in annual benefits for growth amounting to $17,700 ($14,400 in the alternate system).

The growth experienced during the past twenty years, which is continuing today and is expected to continue without additional flood protection, will not be materially hastened by project construction. Consequently, no enhancement benefits have been evaluated.

TABLE A-4

Growth Parameters

Keene, New Hampshire

	1930	1940	1950	1960	1965	1970
Gross National Product (millions of dollars)	91,105	100,680	284,599	504,400	630,000*	790,000*
National Population (millions)	122.8	131.7	150.7	179.3* 169.4#	196.0* 176.3#	214.0* 183.2#
New Hampshire Population (thousands)	465.3	491.5	533.2	606.9		
Cheshire County Population (thousands)	33.7	34.9	38.8	43.3		
Keene, New Hampshire Population (thousands)	13.8	13.8	15.6	17.6		

(*National Planning Association Projections)

(#NENYIAC Projection)

Value Added by Manufacture	1939	1947	1954	1958
New Hampshire, thousands of (Actual dollars)	104,153	306,932	408,826	490,709
New Hampshire, thousands of (1939 dollars)	104,153	153,466	170,344	182,744
Cheshire County, New Hampshire, thousands of (Actual dollars)	9,121	24,001	34,971	46,692
Cheshire County, New Hampshire, thousands of (1939 dollars)	9,121	12,000	14,571	17,293
Keene, New Hampshire, thousands of (Actual dollars)	4,018	11,574	18,556	27,470
Keene, New Hampshire, thousands of (1939 dollars)	4,018	5,787	7,732	10,174

Retail Sales	1948	1954	1958
New Hampshire, thousands of (Actual dollars)	460,782	603,991	703,516
New Hampshire, thousands of (1939 dollars)	460,782	503,325	521,122
Cheshire County, New Hampshire, thousands of (Actual dollars)	29,416	37,318	45,404
Cheshire County, New Hampshire, thousands of (1939 dollars)	29,416	31,098	33,632
Keene, New Hampshire, thousands of (Actual dollars)	19,457	24,735	30,236
Keene, New Hampshire, thousands of (1939 dollars)	19,457	20,628	22,397

7. <u>AVERAGE ANNUAL BENEFITS.</u> - Average annual benefits were derived for the existing Surry Mountain and Otter Brook Reservoirs, the authorized Honey Hill Reservoir, and the recommended Beaver Brook Reservoir by applying estimates of flow reductions, developed by hydrologic analysis, to annual loss data previously computed. The benefits for the Beaver Brook Reservoir were computed on 2 bases: (1) acting next after the completed reservoirs; and (2) acting after both the completed and authorized reservoirs which would affect flood flows and stages in the area. The basic benefit was adjusted upward by 20.9% to reflect the growth projected to occur in the areas of project influence over the next 20 years.

Operation of Beaver Brook Dam and Reservoir, acting next after Surry Mountain and Otter Brook Reservoirs, would result in average annual benefits of $102,200 in the Ashuelot River Basin. Of this total benefit, $97,200 would be realized on Beaver Brook and $5,000 in the reaches of the Ashuelot River downstream from Keene.

Operation of the alternate system, Beaver Brook Dam acting next after Surry Mountain, Otter Brook, and Honey Hill Reservoirs, would result in average annual benefits amounting to $83,500. Annual benefits totalling $81,700 would be realized on Beaver Brook and $1,800 on the Ashuelot River.

Derivation of average annual losses and benefits are illustrated on Plates A-1, A-2 and A-3 for a typical zone in Keene. Table A-V shows benefits to Beaver Brook Dam acting after the two alternative systems.

TABLE A-V

Average Annual Losses and Benefits to Beaver Brook Reservoir

Ashuelot River Basin

(1963 Price Level)

	ANNUAL LOSSES		ANNUAL BENEFITS	
Reach Description	Natural Average Annual Loss	Annual Loss Modified by Surry Mountain and Otter Brook Dams	Beaver Brook Dam next after Surry Mountain and Otter Brook Dams	Beaver Brook Dam next after Surry Mountain, Otter Brook & Honey Hill Dams
Beaver Brook - Beaver Brook Dam site to mouth	$195,800	$ 89,300	$ 97,200*	$81,700*
Ashuelot River - Surry Mountain Dam to mouth of South Branch River	146,900	24,700	3,100*	1,100*
Ashuelot River - Mouth of South Branch River to mouth of Wheelock Brook	17,150	14,500	400*	100*
Ashuelot River - Mouth of Wheelock Brook to mouth of Ashuelot River	78,450	57,500	1,500*	600*
TOTAL	$438,300	$186,000	$102,200	$83,500

*Adjusted to reflect growth during the next 20 years with appropriate discounting for the growth period.

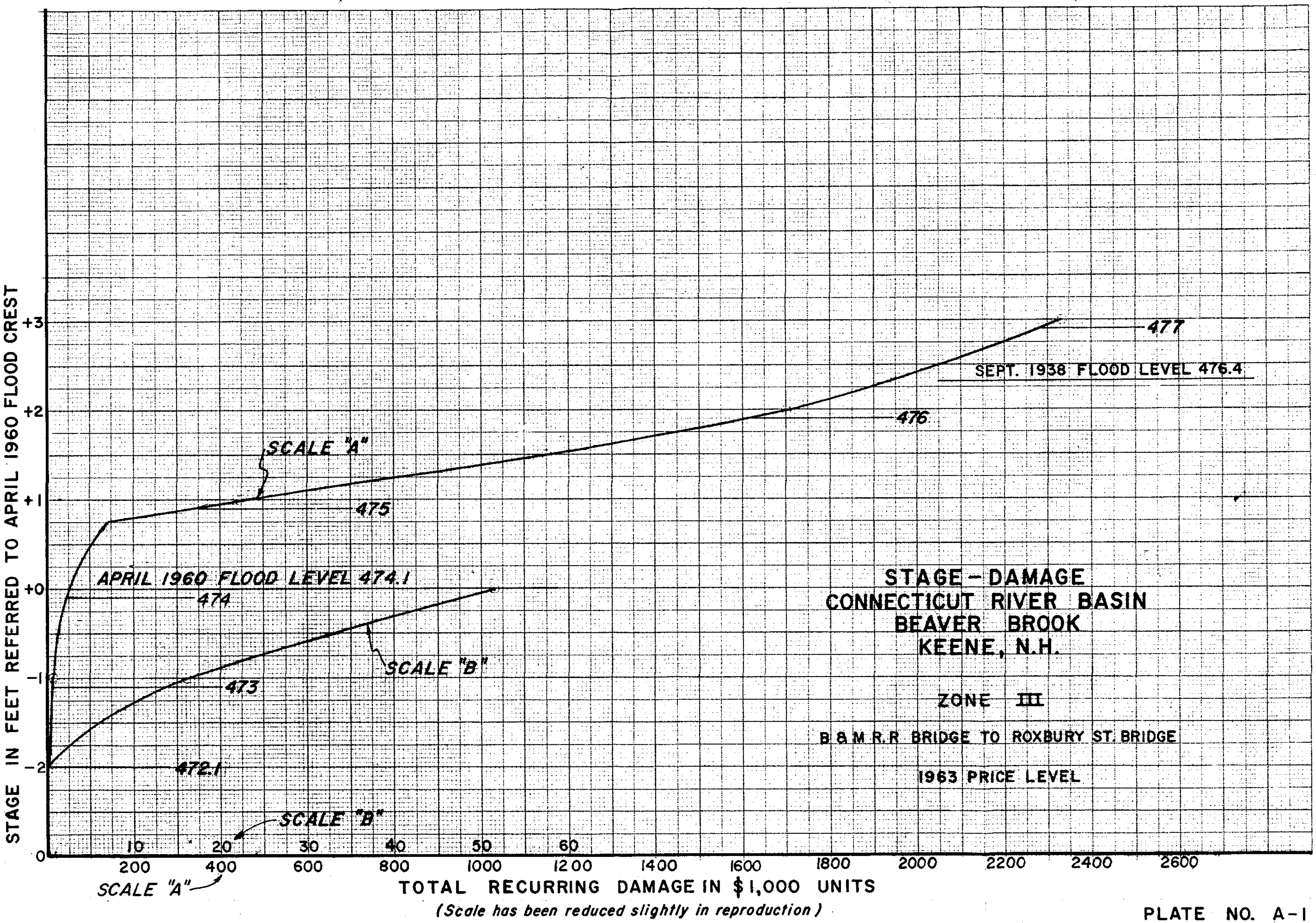
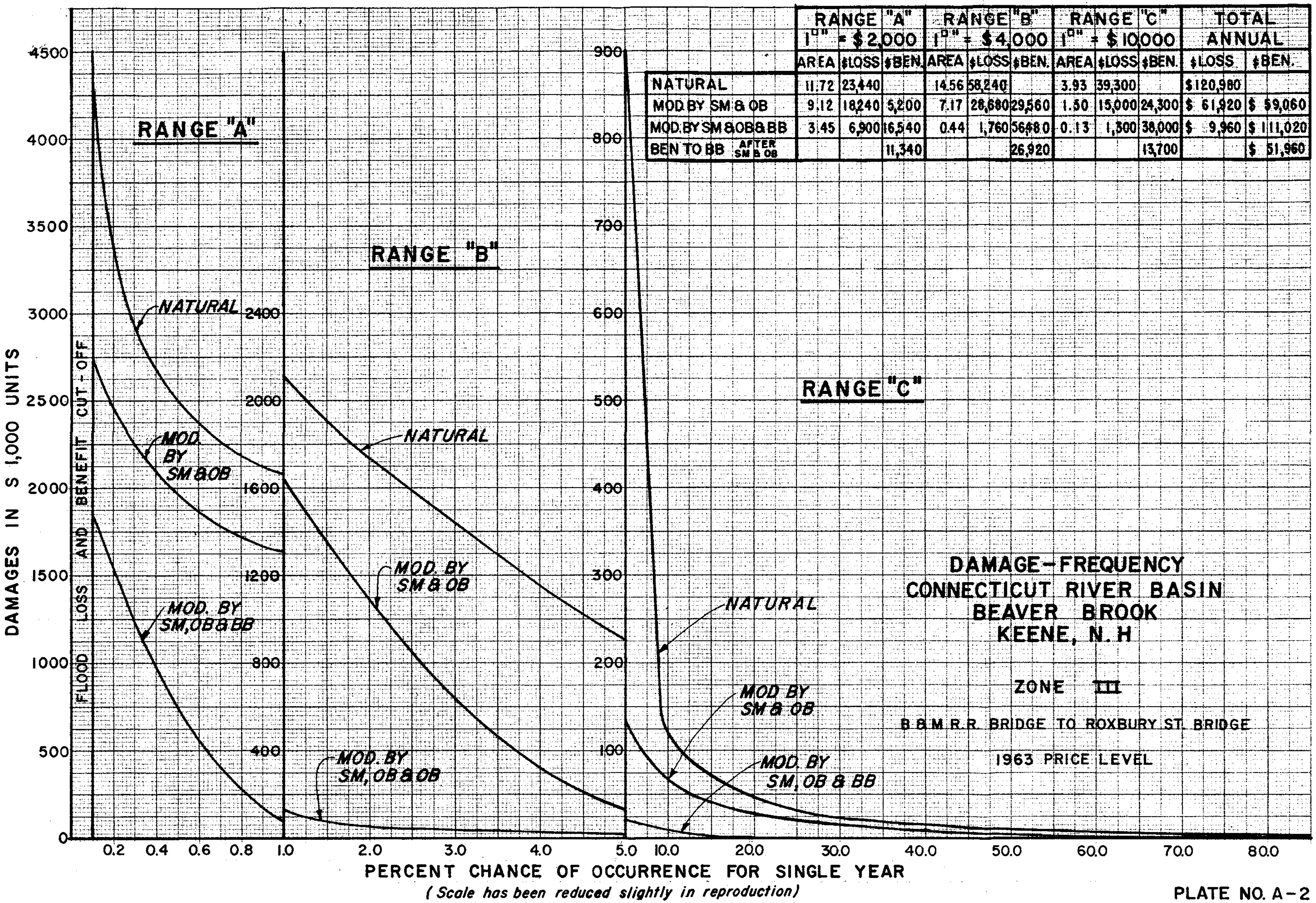

STAGE - DAMAGE
CONNECTICUT RIVER BASIN
BEAVER BROOK
KEENE, N.H.
ZONE III
B & M R.R BRIDGE TO ROXBURY ST. BRIDGE
1963 PRICE LEVEL
STAGE IN FEET REFERRED TO APRIL 1960 FLOOD CREST
TOTAL RECURRING DAMAGE IN $1,000 UNITS
(Scale has been reduced slightly in reproduction)
SEPT. 1938 FLOOD LEVEL 476.4
APRIL 1960 FLOOD LEVEL 474.1
SCALE "A"
SCALE "B"
477
476
475
474
473
472.1
+3
+2
+1
+0
-1
-2
0
10
20
30
40
50
60
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600

PLATE NO. A-1



	RANGE "A" 1□" = $2,000			RANGE "B" 1□" = $4,000			RANGE "C" 1□" = $10,000			TOTAL ANNUAL	
	AREA	$LOSS	$BEN.	AREA	$LOSS	$BEN.	AREA	$LOSS	$BEN.	$LOSS	$BEN.
NATURAL	11.72	23,440		14.56	58,240		3.93	39,300		$120,980	
MOD. BY SM & OB	9.12	18,240	5,200	7.17	28,680	29,560	1.50	15,000	24,300	$ 61,920	$ 59,060
MOD. BY SM & OB & BB	3.45	6,900	16,540	0.44	1,760	56480	0.13	1,300	38,000	$ 9,960	$ 111,020
BEN TO BB AFTER SM & OB			11,340			26,920			13,700		$ 51,960

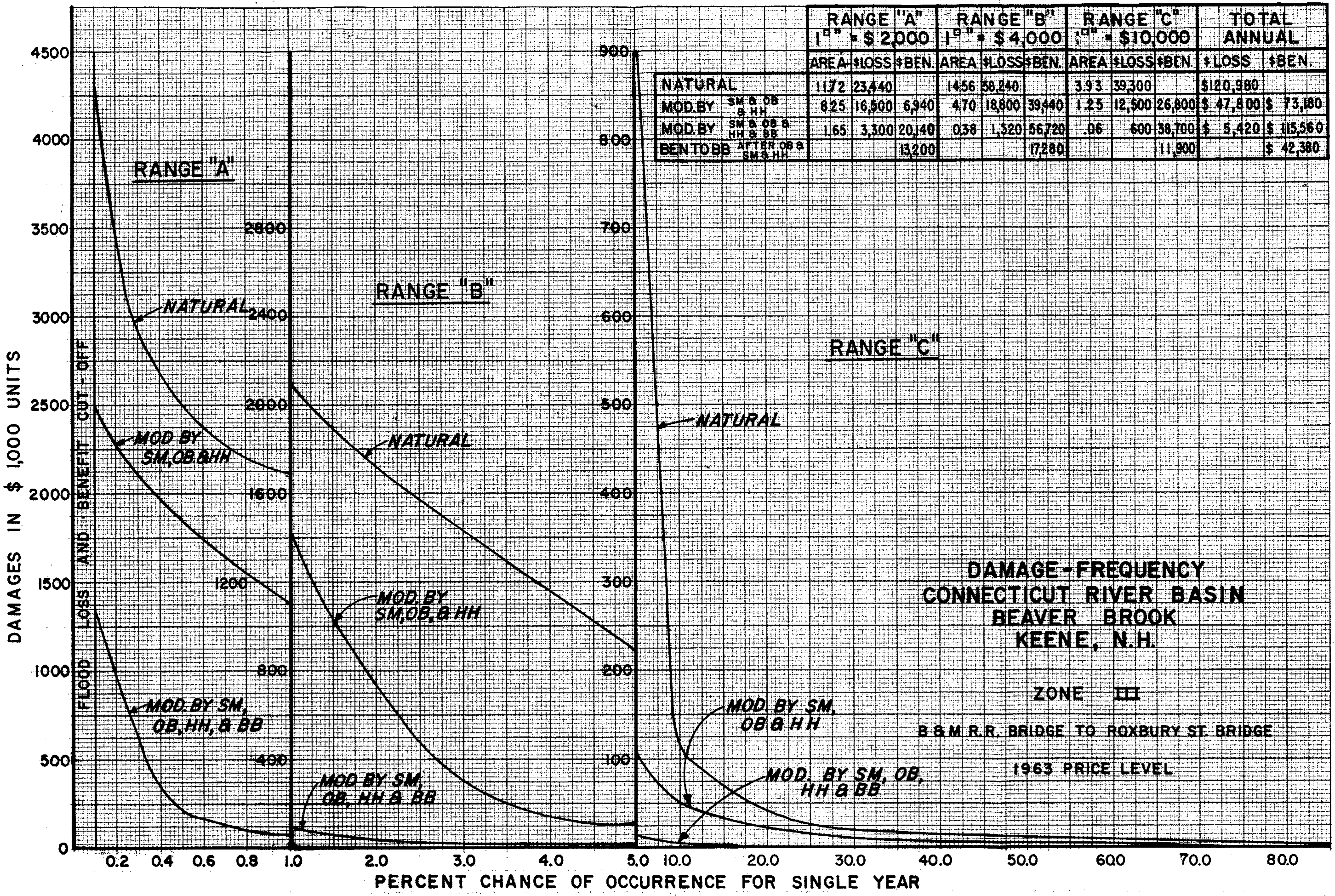
DAMAGE-FREQUENCY
CONNECTICUT RIVER BASIN
BEAVER BROOK
KEENE, N. H

ZONE III

B & M R.R. BRIDGE TO ROXBURY ST. BRIDGE

1963 PRICE LEVEL

PLATE NO. A-2



	RANGE "A" 1□" = $ 2,000			RANGE "B" 1□" = $ 4,000			RANGE "C" 1□" = $10,000			TOTAL ANNUAL	
	AREA	$LOSS	$BEN.	AREA	$LOSS	$BEN.	AREA	$LOSS	$BEN.	$ LOSS	$BEN.
NATURAL	11.72	23,440		14.56	58,240		3.93	39,300		$120,980	
MOD. BY SM & OB & HH	8.25	16,500	6,940	4.70	18,800	39,440	1.25	12,500	26,800	$ 47,800	$ 73,180
MOD. BY SM & OB & HH & BB	1.65	3,300	20,140	0.38	1,320	56,720	.06	600	38,700	$ 5,420	$ 115,560
BEN TO BB AFTER OB & SM & HH			13,200			17,280			11,900		$ 42,380

(Scale has been reduced slightly in reproduction)

PLATE NO. A-3

APPENDIX B

RECOMMENDED PLAN

APPENDIX B

RECOMMENDED PLAN

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APPENDIX B - RECOMMENDED PLAN

1. PROJECT DESCRIPTION. -

a. Reservoir. - The Beaver Brook Dam site is located about 1100 feet upstream of the new Route 9 crossing of the brook. The reservoir at the spillway crest elevation 810.0 m.s.l. would extend about 2 miles up the brook and would have a surface area of approximately 230 acres. The reservoir would have a storage capacity of 3200 acre feet below elevation 810, which would be reserved for flood control. This is equivalent to 10 inches of runoff from the drainage area of 6 square miles.

b. Dam. - The dam, with a top elevation of 825 feet above mean sea level, would be of rolled earth fill with rock slope protection, approximately 990 feet long and with a maximum height of 52 feet above the stream bed. The top would be 20 feet wide. The downstream slope would be 1 vertical on 2.5 horizontal, with 1 vertical on 3.0 horizontal on the upstream slope. A chute-type spillway, with a concrete ogee weir 55 feet in length at crest elevation 810 would be located at the right abutment. The spillway design would be for a ten-foot surcharge, with five feet of freeboard between maximum water level and top of dam.

c. Outlet Works. - The outlet works would consist of a 5-foot by 5-foot cast-in-place rectangular concrete conduit with a conservation weir at the intake structure. The conduit would be gated at the intake structure or throttled by means of an orifice. The conduit would be founded on glacial till with the intake structure founded on bed rock. Control of the permanent pool would be accomplished by means of stoplogs.

d. Provisions for Future Raising. - In order to permit the dam to be raised in the future to provide for water supply, necessary provisions would be made in the project as constructed. The size of the conduit would be increased from 2 feet by 3 feet to 5 feet by 5 feet to permit future installation of the water supply discharge pipe. The design of the conduit would provide for the weight of the additional embankment height. The intake would be founded on bed rock and designed to serve as the foundation of a future intake tower. A 27-inch circular opening would be formed in the spillway weir to provide for a future separate flood control conduit. The opening would be closed with a temporary concrete closure.

e. Pertinent Data. -

TABLE B-I

Dam	
Materials	Rolled earth fill, with rock slope protection
Top Elevation	825 feet, m.s.l.
Top Width	20 feet
Height above stream bed at centerline	52 feet
Length	990 feet
Upstream Slope	1 vertical on 3 horizontal
Downstream Slope	1 vertical on 2.5 horizontal
Spillway	
Peak spillway design flood inflow	8,800 c.f.s.
Peak spillway design flood outflow	5,500 c.f.s.
Crest Elevation	810 feet, m.s.l.
Crest Length	55 feet
Surcharge	10 feet
Freeboard	5 feet
Outlet Works	
Flood Control and Diversion	Box Conduit 5' x 5'
Intake	Orifice or gate in conservation weir
Future water supply line through box conduit	
Future flood control	27-inch conduit in spillway

TABLE B-I (Cont'd)

Reservoir	
Drainage Area	6 square miles
Storage - Flood Control	3,200 acre-feet
Reservoir Area - At Spillway Crest	(810 feet) 230 acres
At Maximum Surcharge	(820 feet) 320 acres
Stream Flow at Damsite	
Maximum Discharge	800 c.f.s.
Average Discharge	9 c.f.s.
Storm of April 1960	310 c.f.s.
Storm of September 1938	800 c.f.s.
Construction Period	
1 Year	

2. GEOLOGY. -

a. General. - The valley of Beaver Brook is physiographically located within the New England Upland in a maturely dissected region of moderately high relief. Glaciation has modified the preglacial bedrock topography by erosion, and to a greater extent by dumped and outwashed deposition of glacial debris from moving and stagnant ice masses. Glacial till, a heterogeneous product of direct deposition, generally blankets the bedrock surface and occasionally in the area has been molded into low hill features known as drumlins. The east-west valley of the Ashuelot River to the north was dammed by glacial till masses creating a temporary glacial lake which may have spilled over the present divide into the north-south valley of Beaver Brook. The till in the lower sides of the valley of Beaver Brook is overlain by remnants of gravelly terraces which were built by melt water streams flowing beside tongues of ice.

Bodies of pegmatite, very coarse-grained granite containing large to giant size crystals of feldspar and often rich in beryl and sheet mica, frequently occur intrusive in the country rocks of this area. There are numerous mines in the pegmatites, but there are no known operations or prospects that would be affected by the construction of the reservoir.

b. Foundations and Materials Investigations. - Subsurface explorations to determine foundation conditions, in general, have consisted of five test borings continuously drive-sampled in overburden to recover 2-1/2 inch diameter samples and core-drilled into bedrock a minimum penetration of 20 feet for recovery of NX(2-1/8-inch) diameter cores. Other subsurface exploration was made by trenching the overburden face of the existing highway cut on the near right abutment. The layout of explorations was based on tentative location of embankment and structures and the results of geologic reconnaissance of the site area. Their distribution for scope of this report was made along the proposed centerline of dam except that one boring (FD-3) was made downstream on the right abutment to determine the elevation of the rock surface in relation to the spillway discharge channel in its proximity to the dam embankment. Locations and records of explorations of records and a generalized geologic section along the centerline of dam are shown on Plate B-1.

Subsurface explorations were not made for borrow sources of natural materials for construction of dam embankment. Random and impervious materials will be available from required excavations and from areas adjacent to the site as indicated surficially and by the results of foundation explorations. Investigation for sources of pervious materials within the reservoir and beyond has been accomplished by geologic reconnaissance.

c. Site Geology. - The proposed centerline of dam is crossed by State Route #10 on the right bank of Beaver Brook about three-tenths of a mile north of its junction with Route #9. The highway at the site cuts the near right abutment just above the brook valley exposing up to about 20 feet of glacial till or till-like material. The topography beyond the top of highway cut is knobby but, in general, is terrace-like for a distance of about 500 feet westerly, where elevation is attained on the main wall of the valley for tie of embankment. Bedrock is not exposed on the right abutment but is indicated at very shallow depth by a knob of detached blocks about 350 feet north of the proposed location of spillway weir. Glacial till (compact, silty, or clayey, gravelly sand) directly overlies the rock surface except for evidences of localized water-laid deposition in the far right abutment area in the vicinity of the spillway. The knobby surface of the right abutment appears to represent superficial dumping of glacial debris consisting of mixed materials, partly reworked and sorted and containing numerous scattered and nested boulders and blocks up to 30 cubic yards in size.

The overburden of the stream section and left abutment is glacial till at or very near the ground surface, and attaining considerable thickness over an easterly dipping rock surface in the left abutment. Boulders are prevalent but size and concentrations do not compare with the superficial condition on the right abutment. Bedrock (schist) somewhat inconclusively outcrops in the stream bed about 200 feet downstream of the proposed centerline of dam at the remains of an old stone dam. The orientation of the schist foliation is essentially that of the trend of the brook valley. There is general concordant foliation in a knoll of schist blocks apparently detached from bedrock about 500 feet upstream of the proposed centerline. These evidences and the intervening explored depth to bedrock on the centerline of dam indicate the rock surface to generally maintain a near ground surface elevation in the stream section throughout this reach.

d. Foundation Conditions. - The compact, impervious nature of the glacial till and its prevalent occurrence near ground surface accessibly provides firm foundation for embankment and conduit and a material in which cutoff can be made for control of under-seepage. The intake control tower required for future water supply will be founded in schist bedrock, the surface of which is indicated at reasonably accessible depth.

Available geologic mapping indicates the schist bedrock to underlie the right abutment. However, present explorations in the spillway area within their depth penetration have encountered only pegmatite (very coarse-grained granite). The pegmatite as indicated by recoveries and condition of core samples should provide firm and tight foundation for the weir structure with little or no preparatory excavation or grouting. The excavation for spillway discharge channel will be bottomed and partially sided in rock for varying but generally shallow depths for some distance beyond the toe of embankment.

e. Reservoir Leakage. - There are no low divides on the limits of the reservoir that require diking. The sides and extremity of the reservoir rise mountainously above maximum flood pool and are faced by exposed bedrock or glacial till over the rock. Cutoff to impervious glacial till will be made under the dam embankment in its major sections.

f. Construction Materials. - Compacted fills of impervious and random type materials constitute the bulk of dam embankment. These materials are available as glacial till, upper weathered till or till-like materials and other near surface materials. Excavations for spillway approach and discharge channel will provide some of the required natural materials and the major portion can be handily supplied by borrowing on either abutment area upstream of the dam.

Pervious fill material is required in the estimated quantity of 10,000 cubic yards for drainage zones in the dam embankment. Sands and gravels principally occur in the valley of Beaver Brook as terrace remnants on the lower right wall. These deposits have largely been depleted for highway construction but portions are preserved a short distance upstream of the damsite under the present highway which will be relocated. Similar deposits occur in the extremity of the reservoir about three miles north and major potential sources are located in the Ashuelot Valley to the north at a haul distance of about six miles.

Rock for embankment fill and slope protection will be partially provided from excavation for the spillway discharge channel. Indications are that shallow excavation will be involved for the most part and with consideration to occurrence of weathered surfaces and pockets, some areas would produce, with regular excavation mathods, little suitable rock no matter what its type. Extent of present explorations indicate that pegmatite will predominate and, although a competent rock insitu, its large crystal structure and particularly heavy micaceous zones will tend to easy breakdown from blasting and during handling and placement. It therefore will be necessary to borrow several thousand yards of suitable rock, some of which may be obtained by direct use, and by breaking of boulders and blocks encountered in stripping and overburden excavation. Excavations for relocation of the highway may provide surplus rock that could be selectively stockpiled for use in the dam embankment. There are no active or abandoned stone quarries in the area. The abandoned mineral mines and quarries in the pegmatite bodies located in the township of Alstead, about seven miles north of the damsite, might provide associated more suitable rocks (gneiss and schist) from waste piles or provide quarry faces in these rocks. However, these possible sources are largely located in mountainous terrain remote from and requiring access improvements to main roads. Excellent quality rock (gneiss) recently removed in rehabilitation of the spillway for Surry Mountain Dam is spoiled in great quantity in that reservoir about four miles airline distance northwest of the Beaver Brook Site. The spoil pile is roughly graded and covered with sand fill and the minimum haul route of about eight miles requires travel through the northern section of the City of Keene. Rock partly exposed in old borrow pits in the terrace remnants upstream of the dam could be further economically exposed for quarrying by borrowing of remaining pervious materials.

Processed materials for gravel bedding and concrete aggregates are available from commercial plants located in Keene and in Walpole, New Hampshire at a maximum haul distance of about 20 miles. Aggregates from both sources have been tested and used in civil works construction.

3. EMBANKMENTS AND FOUNDATIONS. -

a. General. - Design and engineering studies have been made to the extent considered necessary for this report relative to the foundations, embankment and earthwork. A program of investigations consisting of subsurface explorations and field reconnaissance has been made to determine: (1) the characteristics of the foundation soils for the proposed embankment; (2) the characteristics of the materials to be excavated; and, (3) the availability and economics of potential sources of embankment materials. Subsurface explorations for the proposed embankment and structures consisted of 5 drive sample borings and one test trench. In cases where bedrock was encountered during drive sampling the bedrock was core drilled. The location and logs of these explorations are shown on Plate No. B-1. The site geology of the area is described in paragraph 2 of this appendix.

b. Characteristics of Foundation Soils. -

(1) Valley Section. - The overburden in the valley section generally consists of a variable glacial till, overlain in part by a variable sand and gravel deposit of varying thickness, and a minor road fill. The thickness of the overburden in the valley bottom is on the order of 17 feet whereas the overburden on the left abutment is somewhat thicker, being in excess of 25 feet at the location of Boring FD-5. The glacial till occurs from 1 to 5 feet below the surface and in the valley bottom is overlain by a deposit of variable silty sands and gravels of varying thickness. The foundation soils are overlain by topsoil to a depth of less than a foot although in the valley bottom the topsoil occurs to a depth of 2 feet. The glacial till is composed generally of gray, very compact slightly plastic silty and clayey sands (SM-SC and SM) and gravelly sandy clay (CL) with phases of sandy clayey gravel (GC). There are no soft or low shear strength materials and it is estimated that the materials will have shear strength parameters in

excess of $\phi = 30^{\circ}$ and c = 0 TSF. The fine contents of the silty and clayey sands generally range from about 30 to 45 percent, based on the component passing the No. 4 sieve whereas the fine contents of the clayey till range from about 60 to 80 percent based on the component passing the No. 4 sieve. The gravel contents of the clayey till range from 15 to 25 percent. The materials overlying the glacial till consist of variable silty sands and gravels (SM and GP-GM) with cobbles. These materials generally have fine contents on the order of 20 to 30 percent, based on the component passing the No. 4 sieve. The silty sands have gravel contents of about 10 to 20 percent.

(2) Saddle Section. - The overburden in the saddle section on the right abutment consists of a variable deposit of silty sands, silts and clays overlying either the bedrock directly or glacial till. The thickness of this deposit varies from a depth of 17 feet at the location of Boring FD-2, where it overlies the bedrock directly, and diminishes in thickness toward the right abutment until, at the location of FD-4, the thickness of this deposit is only 2 feet overlying glacial till. The thickness of the overburden in this area is on the order of 20 feet. The variable deposit consists generally of variable brown to gray brown, loose to moderately compact, gravelly and silty, fine and medium to fine sand (SM) with phases of sandy silt and clay. The sands generally have fine contents on the order of 20 to 30 percent, based on the component passing the No. 4 sieve, and gravel contents varying from 0 to 30 percent. The underlying glacial till consists of silty and clayey sands (SM-SC and SM) similar to those described in the Valley Section. No soft or low shear strength materials were observed in this area and it is estimated that the shear strength parameters for these materials will be in excess of $\phi = 30^{\circ}$ and c = 0 TSF. The area is generally covered by less than one-foot of topsoil and there are a substantial number of surface boulders, some of which may be as large as 10 cubic yards in volume.

c. Characteristics of Embankment and Fill Materials. -

(1) Materials from Required Excavations. -

(a) Overburden. The materials from the required excavations that will become available for embankment construction will consist of soil from excavations for the inspection trench, conduit and spillway. It is expected that the bulk of the material that will be available for embankment construction will consist of the glacial till and variable sands. The variable sands are similar to those encountered in the saddle section as described previously. Although it is probable that portions of the required excavation would be suitable for use as impervious fill material it is considered that it is more practical to assume that all of the required excavation will be utilized as random fill. Therefore, the stripped material will be wasted and suitable soil from required excavations will be incorporated to the extent practicable, into the embankment in random fill zones.

(b) Rock. The required rock excavation from the spillway channel is expected to be suitable for and will be utilized as rock slope protection and rock fill in the completed embankment. However, the quantity of rock available from required excavation will be insufficient and rock borrow will be required.

(2) Borrow Materials. -

(a) Impervious Materials. - Although it is expected that some material from the required excavations would be suitable for use as impervious fill, it is considered more practical to obtain all of the impervious material from the same source. In this respect, it is anticipated that suitable and sufficient material is obtainable just upstream of and adjacent to the left abutment. It is expected that the material available for use as impervious fill will be a glacial till consisting predominantly of silty and clayey sands (SM and SM-SC) similar to those encountered in the valley section of the embankment.

(b) Random Materials. - It is not expected that the required excavations will produce sufficient material to complete the random portions of the embankment. Based on field reconnaissance of the area, it is considered that sufficient material suitable for use as random fill is available within 1 mile of the site. However, instead of designating a separate borrow area for random fill, it is probable that the borrow area which will be established for impervious fill material can be extended to yield sufficient additional material to complete the random sections of the embankment.

(c) Pervious Materials. - Materials suitable for use as pervious embankment materials are available from commercially developed pits located in Keene, New Hampshire, about 10 miles from the site. In addition, it is possible that sufficient and suitable materials could be obtained from abandoned and undeveloped gravel pits located within the reservoir area. A more detailed investigation would be required to determine the exact extent of the deposits in the reservoir and to determine the characteristics of materials both from the reservoir area and commercial sources.

(d) Rock. The required rock excavation is not expected to produce sufficient material for construction of the embankment and therefore rock borrow will be required. Based on field reconnaissance it is considered that suitable additional rock can be obtained from rock outcrops in the reservoir area within 1 mile of the site.

d. Embankment Design. - The selected section for the dam embankment, shown on inclosure 3 of the Reconnaissance Report is essentially a homogeneous section. It was considered advisable to provide a zone of relatively more impervious and uniform material. The selected section is of the rolled fill central core type with rock slope protection, an internal drainage wick, downstream drainage blanket, a small downstream rock fill toe and an inspection trench. This section was selected to utilize to the maximum extent possible the variable sands and sandy till soils available from required excavations and nearby deposits and to minimize the use of the more costly impervious and pervious fill materials. While it may prove feasible during final design studies for the flood control dam to develop another embankment section which would utilize more material from the required earth excavations, present uncertainties regarding the quantity and characteristics of such material are considered to justify retention of the selected section for the report. From preliminary investigations, it is estimated that the materials available should provide a stable embankment with a downstream slope of 1 on 2.5. Since the characteristics of the available materials have not been fully determined, an upstream embankment slope of 1 on 3 has been selected to insure stability during drawdown. Seepage through the embankment will be controlled by the arrangement of the random and impervious zones, the pervious wick, drainage blanket and downstream rock fill toe. The location and size of the pervious wick was chosen to intercept drainage well within the embankment, thereby preventing the development of seepage pressures detrimental to stability and increasing the overall stability of the embankment. To further control seepage through the foundation, an inspection trench extending below the disturbed zone of frost action will be placed along the centerline of the dam embankment.

e. Foundation Design for Concrete Structures. - The foundations for the concrete structures for the project will be either bedrock or compact glacial till. The foundation for the spillway weir and the intake will be founded on bedrock and the foundations for the outlet works conduit will be founded on compact glacial till material. No significant settlements are expected to occur in the foundations of concrete structures founded on these materials.

4. RELOCATIONS. -

a. Roads. - The highway relocation proposed in this report would conform as nearly as possible to the standards and requirements of the New Hampshire Department of Public Works and Highways and other interested agencies. The construction of the dam would necessitate the relocation of Route 10. The New Hampshire Department of Public Works and Highways had been planning a relocation of Route 10 in the reservoir area when the Beaver Brook studies were initiated. This relocation was deferred pending the results of the studies. Present estimates include only the cost of relocation over and above that of the originally contemplated state relocation. The length of relocated state road for the flood control dam and for the multi-purpose flood control water supply dam would be 1.7 miles and 3 miles, respectively. Sullivan Road would also require relocation or raising.

b. Utilities. - Relocations of utilities in connection with the construction of Beaver Brook Dam and Reservoir would involve telephone and 2400-volt electrical utility lines on both Route 10 and Sullivan Road. In addition, a 115 kv transmission line crosses the reservoir area about 1200 feet north of the site of the proposed dam. The estimated cost of utility relocations would be sufficient for either the multi-purpose or the flood control plan.

5. REAL ESTATE. -

a. Reservoir Areas. - Pool areas within the proposed reservoir would be approximately as follows:

Pool	Elev. in feet	Area in Acres
Spillway crest elev.	810	230
Maximum surcharge	820	320

b. Land Acquisition. - The elevation of maximum surcharge (spillway design flood) for the guide taking line for minimum land acquisition is considered desirable in order that there be no possibility of private lands being flooded, with resultant damages to the City of Keene. Inasmuch as the City is considering future multi-purpose development with water supply storage included, there would be little or no associated recreational development to justify the acquisition of additional marginal areas. Local interests may consider further acquisition desirable for other purposes, however, such as control of additional areas of the watershed for maintenance of high standards of water quality. Actual extent of land acquisition would be in accordance with established policy at the time of final design. Provisions of EM 405-2-150 on land acquisition policy are considered inapplicable, inasmuch as lands and rights-of-way are to be acquired by local interests.

6. FIRST COSTS. - First costs are given in Table B-II on page B-16 of this appendix. Cost of the second stage is given in Table B-V.

7. ANNUAL CHARGES. - Annual charges are given in Table II on page 14 of this report.

8. WATER SUPPLY CONSIDERATIONS. -

a. General. - The City of Keene is currently considering the problem of future water supply needs, and is faced with the necessity of augmenting its supply within the immediate future (see Paragraph 25b). Preliminary findings suggested that development of water supply storage in the proposed Beaver Brook Reservoir might be the most feasible source of additional supply for the City.

b. Present Supply. - The City water supply consists of Babbidge Reservoir, augmented by Woodward Pond and one producing well. Water from the reservoir is treated by filtration and chlorination. The well water is chlorinated. The system includes two storage tanks with a total capacity of 4.5 million gallons for meeting peak demands. The estimated safe yield is 3.5 M.G.D. (million gallons per day) with a capacity yield of 4.5 M.G.D. With an increasing population and continuing industrial expansion, Keene is fast approaching the point where demand will exceed the minimum yield of a dry year. In the Summer of 1963 demand was substantially equal to the supply for an extended period during which the storage tanks could not be completely refilled.

c. Future Supply. - Recent investigations including pumping tests demonstrated the possibility of developing three additional wells. The City is acquiring lands and is planning to add these three wells, with a total yield of 3 M.G.D., to its system. These added wells are expected to meet the City's needs for about 16 years, after which additional sources will be needed. Investigations have shown that potential well sites are limited and that development of additional wells at that future time is unlikely. Consequently the City must look to development of surface waters as the next stop. Development of Beaver Brook to provide additional water is a logical solution to the long range problem. This development would require about three miles of pipe line. There is also the probability that filtration will be required.

d. Economic Considerations. (1) Wells. - The three wells are estimated to cost about $130,000, $70,000, and $200,000 respectively, including pipeline connections. Cost of the site and pipeline for the second well is included in that for the first. Annual costs of pumping are estimated at $5,000 per M.G.D. Annual costs were computed assuming an average cost of $133,000 per well, an interest rate of 3 percent and amortization over 50 years. On this basis the annual cost per M.G.D. is about $11,800. Use of wells permits the addition of relatively small increments of capacity as needed without large capital expenditures for future capacity.

(2) Beaver Brook Supply. - If the Beaver Brook supply were to be used immediately, the allocated cost for water supply as shown in Table No. D-XI would be $748,000. In addition to paying the allocated cost of the dam construction, the City would have to construct a pipeline about 3 miles in length costing an estimated $300,000 and might also have to construct a filtration plant estimated to cost $750,000. Interest and amortization on these items has been computed on the basis of a 50-year repayment period for the dam and 50-year life for the filtration plant and pipeline, all with 3 percent interest rate. Approximate annual water supply costs are tabulated in Table B-III below.

TABLE B-III

ANNUAL WATER SUPPLY COSTS
(water supply used immediately)

Item	Amount	Total
DAM, Water Supply Portion		
Interest, water supply portion (.03x$748,000)	$22,440	
Amortization (.00887x$748,000)	6,630	
Maintenance and Operation	3,185	
Major Replacements	970	
Tax Loss on Land	560	
Sub-Total		$33,785

TABLE B-III (Cont'd)

Item	Amount	Total
Sub-Total (Brought Forward) (DAM)		$33,785
PIPELINE		
Interest (.03 x $300,000)	$ 9,000	
Amortization (.00887 x $300,000)	2,660	
Maintenance and Operation	2,000	
Major Replacements	340	
Sub-Total (PIPELINE)		$14,000
Sub-Total without FILTRATION		$ 47,785
FILTRATION PLANT		
Interest (.03 x $750,000)	$22,500	
Amortization (.00887 x $750,000)	6,650	
Maintenance and Operation	10,000	
Major Replacements	850	
Sub-Total (FILTRATION PLANT)		$40,000
TOTAL WITH FILTRATION		$87,785

As the Beaver Brook supply would provide 4 M.G.D. the cost per M.G.D. would be one fourth as great or about $11,950 without filtration and $21,950 with filtration.

(3) Selection of Plan. - Pertinent data for the alternative plans including estimates were furnished the City Officials. Information on repayment provisions provided by the Flood Control Act of 1958, as amended, was included. After considering the effect of these plans on the City's finances and water rates the City Council selected the flood control dam with minimum provisions for future raising. This has the advantages of keeping the City's expenditures at a minimum while leaving the way open to future development. In arriving at this decision the City considered the effect of interest charges accumulating over the period of years before the storage would be used.

(4) Cost with Two Stage Construction. - The allocated cost of two stage construction for water supply is $535,000, including $309,000 for present worth of future construction costs. Average annual costs over the next 50 years are tabulated in Table B-IV below.

TABLE B-IV

ANNUAL WATER SUPPLY COSTS
(Two Stage Construction - Water Used in 16 Years)

DAM, Water Supply Portion		
Interest, water supply portion (.03 x $535,000)	$16,010	
Amortization (.0887 x $535,000)	4,750	
Maintenance and Operation	1,880	
Major Replacements	560	
Tax Loss on Land	480	
Sub-Total, Dam		$23,680
Pipeline 0.6232 x 14,000		8,720
Filtration Plant 0.6232 x 40,000		24,930
TOTAL, with filtration		$57,330

TABLE B-II

FIRST COST

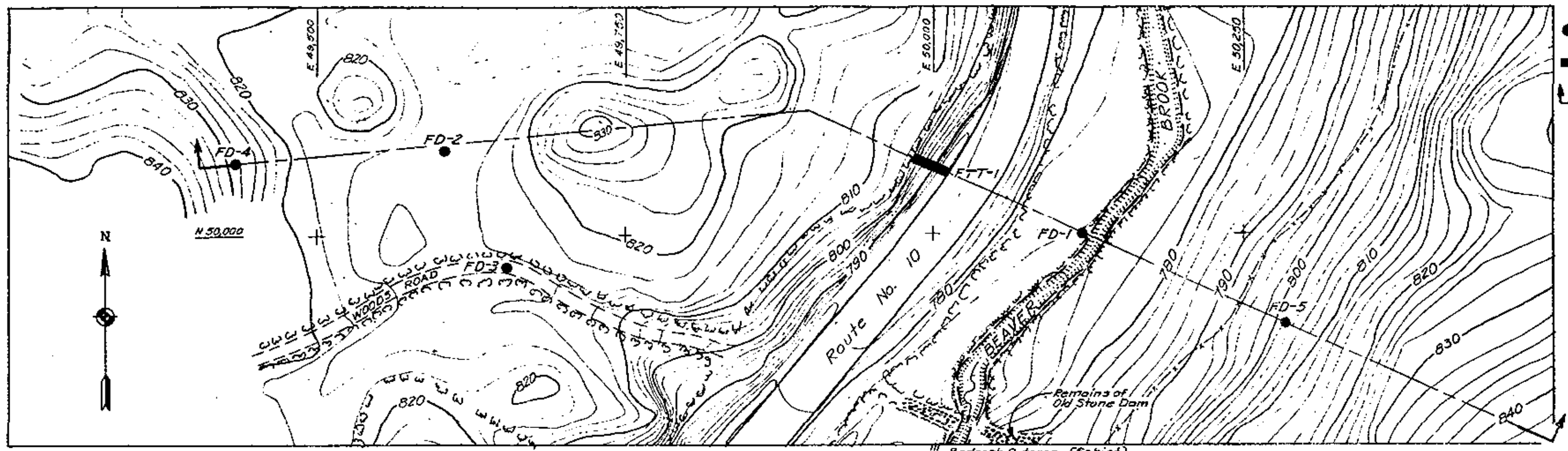
BEAVER BROOK DAM
(1963 Price Level

Item	Estimated Quantity	Unit	Unit Price	Amount	Total
LANDS, DAMAGES AND RELOCATIONS					
Lands to Elev. 820 msl		L.S.		$140,000	
Extra lands to Elev. 828		L.S.		40,000	
Relocations, Roads		L.S.		110,000	
Extra road relocation costs		L.S.		66,000	
Relocations, Utilities		L.S.		50,000	
TOTAL					$ 406,000
RESERVOIR CLEARING	10	Acre	500		5,000
DAM					
Preparation of Site	7	Acre	600	$ 4,200	
Stream Control		L.S.		1,500	
Earth Exc., common	91,000	C.Y.	0.60	54,600	
Rock Excavation	10,000	C.Y.	4.00	40,000	
Impervious Borrow	26,000	C.Y.	0.60	15,600	
Impervious Fill (placing)	24,800	C.Y.	0.25	6,200	
Pervious Fill (in place)	10,600	C.Y.	1.00	10,600	
Random Fill (placing)	30,000	C.Y.	0.20	6,000	
Gravel Bedding (in place)	9,000	C.Y.	2.00	18,000	
Rock Borrow	3,000	C.Y.	4.20	12,600	
Rock Fill (placing)	12,000	C.Y.	1.00	12,000	
Concrete	2,500	C.Y.	35.00	87,500	
Conduit, complete		L.S.		36,000	
Miscellaneous items		L.S.		30,500	
Sub-Total				335,300	
Contingencies				67,700	
TOTAL					403,000
ACCESS ROAD					28,000
MISC. EQUIPMENT					24,000
BUILDINGS, GROUNDS & UTILITIES					10,000
TOTAL DIRECT COSTS					876,000
INDIRECT COSTS					
Engineering and Design				105,000	
Supervision and Administration				45,000	
TOTAL INDIRECT COSTS					150,000
TOTAL PROJECT FIRST COST					$1,026,000

TABLE NO. B-V

SECOND STAGE CONSTRUCTION
FIRST COST
(1963 Price Level)

Item	Estimated Quantity	Unit	Unit Price	Amount	Total
Reservoir Clearing	90	Acre	500	$	$ 45,000
Dam Embankment					
Earth Excavation, Dam	4,000	C.Y.	.70	2,800	
Exc. backfill at spillway	4,000	C.Y.	1.40	5,600	
Compacted Imperv fill	13,000	C.Y.	1.00	13,000	
Compacted Random Fill	21,000	C.Y.	.90	18,900	
Gravel Bedding	6,800	C.Y.	2.40	16,320	
Gravel Blanket	3,900	C.Y.	2.00	7,800	
Rock protection, salvage & place	5,200	C.Y.	1.20	6,240	
Rock protection, furnish & place	3,400	C.Y.	5.50	18,700	
Road gravel, salvage & place	1,800	C.Y.	1.30	2,340	
Remove discarded structures		L.S.		800	
Sub-total				$92,500	
Contingencies				18,500	
TOTAL DAM AND EMBANKMENT					111,000
Concrete					
Outlet Works	70	C.Y.	60.00	4,200	
Control tower above 790	290	C.Y.	90.00	26,100	
Weir	270	C.Y.	40.00	10,800	
Bond & tie to exist. weir		L.S.		2,400	
Retaining walls	1,300	C.Y.	40.00	52,000	
Bridge abutment	180	C.Y.	45.00	8,100	
Conduit extension	75	C.Y.	65.00	4,875	
Sub-Total				$108,475	
Contingencies				21,525	
TOTAL CONCRETE					130,000
Access Road		L.S.			1,000
Service Bridge		L.S.			35,000
Miscellaneous Equipment		L.S.			30,000
Bldgs, Grounds, & Utilities		L.S.			15,000
TOTAL DIRECT COST					$367,000
Indirect Cost					
Engineering & Design				92,000	
Supervision & Administration				37,000	
TOTAL INDIRECT COST					129,000
TOTAL PROJECT FIRST COST					$496,000



PLAN

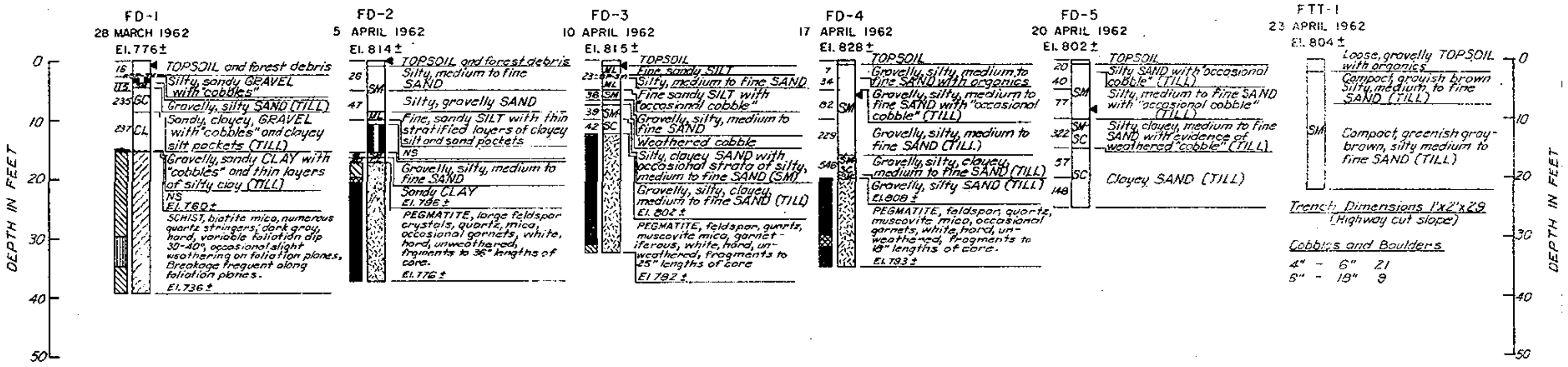
SCALE 1" = 50'

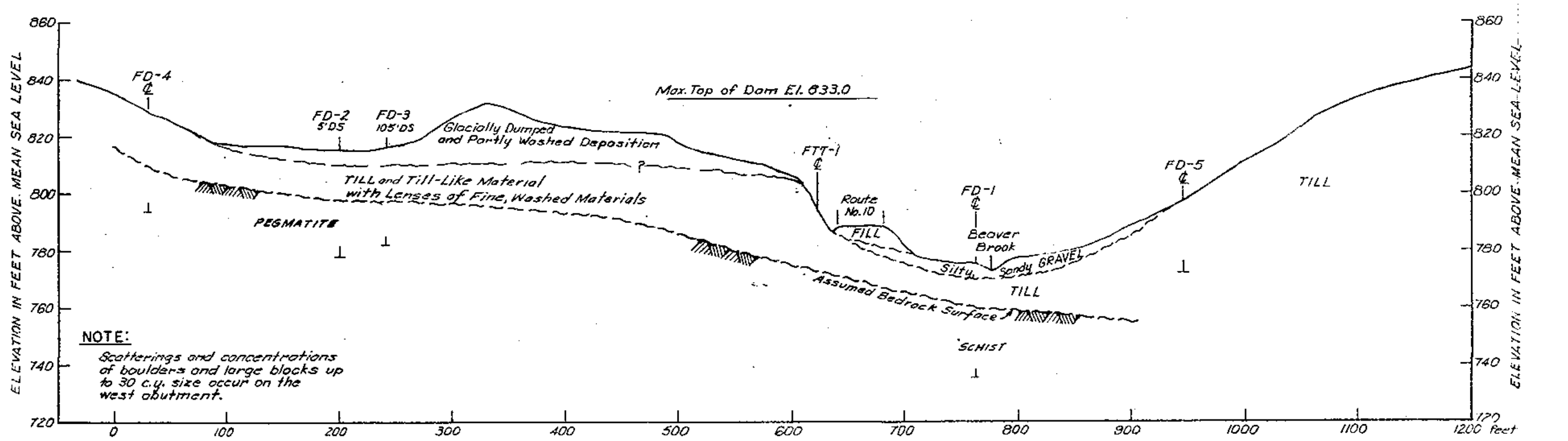
LEGEND FOR PLAN

- FD-1 Foundation Test Boring
- FTT-1 Foundation Test Trench
- Geologic Section

LEGEND FOR GRAPHIC LOGS

- FD-1 Foundation Test Boring
- FTT-1 Foundation Test Trench
- 5 APRIL 1962 Date exploration completed
- El. 814 Elevation of ground surface during time of exploration
- Subsurface water level in boring at time of exploration.
- SM Group letter symbol according to Unified Soil Classification System.
- NR No Recovery or unsatisfactory soil samples recovered.
- NS Not Sampled Hole advanced by core-drilling, blasting and/or wash boring due to operational difficulty.
- CD Sampling in overburden by core-drilled method.
- 25 Blows per foot of penetration considered most representative for each sample drive using a 300 or 350 pound hammer with a free fall of about 18" on a 1½" I.D. or 2" O.D., 2" I.D. or 2½" O.D. and/or 2½" I.D. or 3" O.D. size sample spoon equipped with a beveled and sharpened drive shoe.
- * Blow counts not recorded or not considered representative.
- Cobble or boulder (Core drilled)
- Cobbles or boulders, continuous or nested (Core-drilled and/or blasted and chopped
- El. 776.0 Elevation of bedrock surface
- Rock symbol
- El. 720.0 Elevation bottom of exploration
- Rock core recovery 0-25%
- Rock core recovery 25-50%
- Rock core recovery 50-75%
- Rock core recovery 75-90%
- Rock core recovery 90-100%





NOTE:

Scatterings and concentrations of boulders and large blocks up to 30 c.y. size occur on the west abutment.

GEOLOGIC SECTION ON ℄ DAM

(LOOKING UPSTREAM)

GRAPHIC SCALE

50' 0 50' 100'

1" = 50'

NOTES

Elevations refer to Mean Sea Level Datum.
Contour interval is 2 feet.

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

DES. BY | DR. BY RDB | CK. BY

SUBMITTED

PROJECT ENGINEER

APPROVAL RECOMMENDED
CHIEF, FOUNDATIONS & MATLS BRANCH

APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH

CONNECTICUT RIVER FLOOD CONTROL

BEAVER BROOK

GEOLOGY

BEAVER BROOK, NEW HAMPSHIRE

APPROVED
CHIEF, ENGINEERING DIVISION

DATE SEPT. 1963

SCALE AS SHOWN | SPEC. NO CIV. ENG.-19-016

DRAWING NUMBER

SHEET

APPENDIX C

OTHER PLANS CONSIDERED

APPENDIX C

OTHER PLANS CONSIDERED

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APPENDIX C

OTHER PLANS CONSIDERED

1. GENERAL.-As alternatives to the recommended plan, consideration was given to a single purpose flood control project and to a multi-purpose project for flood control and water supply. The annual costs of a dam for water supply only were used for evaluating the benefits of the water supply portion of the multi-purpose dam.

2. MULTI-PURPOSE PROJECT, SINGLE STAGE CONSTRUCTION. -

a. Reservoir.-The site for the multi-purpose plan is the same as for the recommended plan, about 1100 feet upstream from the new Route 9 crossing of the brook. The water supply reservoir at the overflow flood control weir at Elevation 808.5 would extend about 2 miles up the brook and would have a surface area of about 220 acres. At the spillway crest elevation of 820 feet m.s.l., the reservoir would extend about 2.9 miles up the brook and would have a surface area of 320 acres. The reservoir would have a storage capacity of 6200 acre-feet above elevation 782, of which 3200 acre-feet would be reserved for flood control. This is equivalent to 10 inches of runoff from the drainage area of 6 square miles. Below the lower water supply intake (elev. 782) there would be about 75 acre-feet of dead storage.

b. Dam.-The dam, with a top elevation of 833 feet m.s.l. would be of rolled earth fill with rock slope protection, approximately 1050 feet long and with a maximum height of 60 feet above the stream bed. The top would be 20 feet wide. The downstream slope would be 1 vertical on 2.5 horizontal, with 1 vertical on 3.0 horizontal on the upstream slope. A chute type spillway, with a concrete ogee weir 55 feet in length and crest elevation of 820 feet m.s.l. would be located at the right abutment. The spillway design would be for an 8 foot surcharge, with 5 feet of freeboard between maximum water level and top of dam. The flood control outlet works would consist of an ungated 27 inch conduit through the spillway crest, with a simple overflow weir intake at elev. 808.5 feet and an invert elevation of 800 feet. The drainage and water supply outlet works would consist of a cast-in-place concrete box conduit founded on earth, with an outlet structure and a concrete intake tower, gated for future water supply use. Drainage and diversion flow would enter the intake tower through a gate at the bottom, and pass through the conduit. Water supply would enter the intake tower through 2 gates at invert elevation 782 and elevation 800, pass through fixed screens and into the water supply line to be installed through the conduit at a later date. Access to the intake tower would be by means of a single-span service bridge from the top of the dam. The construction period of the dam is estimated to be 1.5 years.

c. Pertinent Data.-Multi-purpose, single stage project. -

TABLE C-I
Pertinent Data
Multi-Purpose Project
Single Stage Construction

Dam

Materials - Rolled earth fill, with rock slope protection
Top Elev. - 833 feet, m.s.l.
Top Width - 20 feet
Height above stream bed at center line - 60 feet
Length - 1050 feet
Upstream Slope - 1 vertical on 3 horizontal
Downstream Slope - 1 vertical on 2.5 horizontal

Spillway

Peak spillway design flood inflow - 8800 c.f.s.
Peak spillway design flood outflow - 4800 c.f.s.
Crest elevation - 820 feet m.s.l.
Crest length - 55 feet
Surcharge - 8 feet
Freeboard - 5 feet

Outlet Works

Flood control - Ungated conduit through spillway crest
Drainage and Diversion - Box conduit, 5' x 5'
Water supply - Intake tower, gated
Future water supply line through box conduit

Reservoir

Drainage area - 6 square miles
Storage - Flood Control - 3,200 acre feet
Water Supply - 3,000 acre feet
Total - 6,200 acre feet at spillway crest

Reservoir Area -	At water supply pool	(808.5)	- 220 acres
	At spillway crest	(820)	- 320 acres
	At maximum surcharge	(828)	- 390 acres

Stream Flow at Dam Site

Maximum discharge	- 800 c.f.s.
Average discharge	- 9 c.f.s.
Storm of April 1960	- 310 c.f.s.
Storm of September 1938	- 800 c.f.s.

Construction Period - 1.5 years

d. First Costs and Annual Charges. -

TABLE C-II
First Costs and Annual Charges
Multi-Purpose Project
Single Stage Construction

Item		Amount
(1) First Costs		
Lands and Damages		$ 180,000
Relocations		226,000
Reservoir Clearing		50,000
Dam		550,000
Misc. (structures, equip., etc.)		153,000
Engineering and Design		151,000
Supervision and Administration		70,000
TOTAL FIRST COSTS		$1,380,000
(2) Annual Charges		
Interest (.03 x $1,380,000)		$41,400
Amortization (.00887 x $1,380,000)		12,240
Maintenance and Operation		
First 16 years, 4000 x 12.561 x .03887 =	1,950	
Last 34 years, 6000 x 21.132 x .6232 x .03887 =	3,070	
TOTAL, (rounded)		5,000
Major Replacements		1,400
Economic Adjustment for Net Loss of Taxes in Gilsum		1,600
TOTAL ANNUAL CHARGES		$61,640

e. Single Purpose Water Supply Project.-

TABLE C-III
First Costs and Annual Charges
Single Purpose Water Supply Project

Item	Amount
(1) First Costs	
Lands and Damages	$ 134,000
Relocations	160,000
Reservoir Clearing	50,000
Dam	400,000
Misc. (structures, equip., etc.)	107,000
Engineering and Design	104,000
Supervision and Administration	55,000
TOTAL PROJECT FIRST COST	$1,010,000
Interest during Construction	0
TOTAL INVESTMENT	$1,010,000
(2) Annual Charges (Non-Federal)	
Interest (.03 x $1,010,000)	$30,300
Amortization, 50-years (.00887 x $1,010,000)	8,960
Maintenance and Operation	3,570
Major Replacements	1,000
Loss of taxes on land	1,400
TOTAL ANNUAL CHARGES	$45,230

3. <u>SINGLE PURPOSE FLOOD CONTROL PROJECT</u>. -

a. <u>Reservoir</u>. - The site for the single purpose flood control plan is also the same as for the recommended plan, about 1100 feet upstream from the new Route 9 crossing of the brook. The reservoir at the spillway crest elevation of 810.0 m.s.l. would extend about 2 miles up the brook and would have a surface area of approximately 230 acres. The reservoir would have a storage capacity of 3200 acre feet above elevation 782 which would be reserved for flood control. This is equivalent to 10 inches of runoff from the drainage area of 6 square miles.

b. <u>Dam</u>. - The dam, with a top elevation of 825 feet above mean sea level, would be of rolled earth fill with rock slope protection, approximately 900 feet long and with a maximum height of 52 feet above the stream bed. The top would be 20 feet wide. The downstream slope would be 1 vertical on 2.5 horizontal, with 1 vertical on 3.0 horizontal on the upstream slope. A chute-type spillway, with a concrete ogee weir 55 feet in length at crest elevation 810, would be located at the right abutment. The spillway design would be for a 10-foot surcharge with five feet of freeboard between maximum water level and top of dam. The flood control outlet works would consist of an ungated 2'x3' cast-in-place rectangular concrete conduit with conservation weir at the inlet. The overflow crest elevation would be adjustable by use of stoplogs between elevation 786 and elevation 790. Invert elevation would be at elevation 776. Drainage and diversion flow, controlled by a manually operated gate, would enter the same intake and pass through the conduit.

c. Pertinent Data - Single Purpose Flood Control Project. -

TABLE C-IV
Pertinent Data
Single Purpose Flood Control Project

Dam

Materials - Rolled earth fill, with rock slope protection
Top Elevation - 825 feet, m.s.l.
Top Width - 20 feet
Height above stream bed at centerline - 52 feet
Length - 990 feet
Upstream Slope - 1 vertical on 3 horizontal
Downstream Slope - 1 vertical on 2.5 horizontal

Spillway

Peak spillway design flood outflow - 5,500 cfs
Crest Elevation - 810 feet, m.s.l.
Crest Length - 55 feet
Surcharge - 10 feet
Freeboard - 5 feet

Outlet Works

Flood Control - Ungated box conduit, 2' x 3'
Drainage and Diversion - Same conduit (flood control, above)

Reservoir

Drainage Area - 6 square miles
Storage - 3,200 acre-feet
Reservoir Area at Spillway Crest (810) - 230 Acres
Reservoir Area at Max. Surcharge (820) - 320 Acres

Construction Period - One year

d. First Costs and Annual Charges. -

TABLE C-V
First Costs and Annual Charges
Single Purpose Flood Control Project

Item	Federal	Non-Federal	Total
(1) FIRST COSTS			
Lands and Damages	$ 0	$140,000	$140,000
Relocations	0	160,000	160,000
Reservoir Clearing	5,000	0	5,000
Dam	383,000	0	383,000
Misc. (Structures, equip., etc.)	62,000	0	62,000
Engineering and Design	102,000	0	102,000
Supervision & Administration	43,000	0	43,000
	$595,000	$300,000	$895,000
(2) ANNUAL CHARGES			
Interest			
(.03 x $595,000)	$ 17,850	$ 0	$ 17,850
(.03 x $300,000)	0	9,000	9,000
Amortization, 50-year life			
(.00887 x $595,000)	5,280	0	5,280
(.00887 x $300,000)	0	2,660	2,660
Maintenance and Operation	0	3,000	3,000
Major Replacements	0	450	450
Economic adjustment for net loss of taxes or productivity	0	1,440	1,440
	$ 23,130	$16,550	$39,680

APPENDIX D

COST ALLOCATION STUDIES

APPENDIX D

COST ALLOCATION STUDIES

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APPENDIX D

COST ALLOCATION STUDIES

1. GENERAL. - The Beaver Brook Project is located on Beaver Brook in the City of Keene, New Hampshire. The project is currently in the Reconnaissance Report stage pending authorization under Section 205 of the Flood Control Act approved 30 June 1948, as amended. These cost allocation studies have been prepared in accordance with 1st Indorsement of the Chief of Engineers, dated 20 August 1963, Subject: Reconnaissance Report, Beaver Brook, Keene, New Hampshire. In accordance with the referenced indorsement, the Separable Cost-Remaining Benefits method has been used.

2. PLAN OF IMPROVEMENT. -

a. Project Authorization. - The project has not been authorized. A Survey Report was authorized by recommendation of the Senate Committee on Public Works adopted 3 October 1960. A Reconnaissance Report was submitted on 20 March 1963 recommending preparation of a Detailed Project Report for the proposed project.

b. Related Improvements. - The relationship of the proposed Beaver Brook Project with existing and authorized flood control projects in the Keene area is discussed in Section F of this Reconnaissance Interim Report.

c. Operational Requirements. - The project will operate automatically for flood control as a retarding basin with ungated outlet. It is expected that the water supply storage will be operated in connection with other projects of the Keene Water Supply System to furnish domestic water. Inasmuch as the addition of wells to the present system is more economical at this time, it is expected that the water supply needs will not develop until some time after completion of the flood control construction. Accordingly, the water supply benefits have been discounted to present worth in these cost allocation studies.

3. AUTHORIZATION FOR ALLOCATION OF COSTS. - The allocation of cost is prepared on the basis of the Separable Cost-Remaining Benefits method in accordance with Paragraph 4 of the referenced Indorsement of 20 August 1963.

4. DESCRIPTION OF PROJECT. - The proposed Beaver Brook Project is described in Paragraph 27 and Appendix B of this report.

Pertinent data is given in Table No. D-I, Pertinent Data. The additional cost of the conduit to provide for future raising is included as a specific requirement for water supply in the first stage construction. In the second stage, specific requirements consist of reservoir clearing, water supply gates, intake tower, and service bridge, all of which are attributable to the water supply function. However, the cost of the intake tower and service bridge are increased as a result of inclusion of the flood control function in the project. The additional costs of these structures is allocated as a specific cost to flood control. These specific costs are indicated in Table No. D-II, Summary of Construction Expenditures. All other costs are joint costs.

5. CONSTRUCTION PROGRAM. - It is proposed to prepare plans and specifications for the Beaver Brook Project during calendar year 1964, and to construct the dam in the 1965 construction season. It is expected that the dam will be available for flood control operation in the Spring of 1966. The highway relocation will be accomplished in the 1964 and 1965 construction seasons. Water supply storage will not be available until completion of the second stage of construction.

6. PROJECT COSTS AND CHARGES. -

a. Construction Expenditures. - The total construction costs, including lands and relocations are estimated at $1,522,000, all at 1963 price levels. The first stage construction is estimated to cost $1,026,000. The initial or first stage construction includes lands and relocations for the ultimate project at a cost of $40,000 and $66,000 respectively. Also included is the additional cost of providing for the multiple-purpose project in the conduit design. The second stage construction is estimated to cost $496,000 at 1963 price levels. This expenditure, expected to occur in 16 years, has a present worth of $309,000 when discounted at 3 percent. Cost breakdown is shown in Table No. D-II, Summary of Construction Expenditures. Cost breakdown for a single-stage project is shown in Table No. D-VI, Single-Stage Construction, Summary of Construction Expenditures.

b. Operation and Maintenance. - Operation and maintenance is estimated on the basis of experience with other projects. For the first 16 years operation and maintenance is estimated to cost $3,000 annually. After the second stage is constructed, operation and maintenance increases to $6,000 annually. Average annual operation and maintenance costs allocated over the 50-year life of the project are $2,655 for flood control and $1,875 for water supply. Major replacements are estimated to cost $450 annually for the first 16 years. After the second stage is constructed, the cost increases to $1,400 annually. Average annual costs allocated over the life of the project are $385 for flood control and $555 for water supply.

c. Tax Loss on Land. - Loss of taxes on land in the Town of Gilsum is allocated as a joint cost. Flood control and water supply allocations are $1,045 and $475 respectively.

d. Interest during Construction. - As the project is expected to be completed in approximately one year, there is no interest during construction.

e. Annual Charges. - Annual charges are computed on the basis of the project life of 50 years with interest rate of 3 percent. Annual charges are shown in Table No. II, Annual Charges on page 14 of this Reconnaissance Interim Report.

7. PROJECT BENEFITS. -

a. Flood Control Benefits. - Annual flood control benefits are $102,200. Damage surveys and basis for estimate of flood losses and benefits are discussed in Appendix A of this Reconnaissance Interim Report.

b. Water Supply Benefits. - Water supply benefits are estimated on the basis of a single purpose water supply project constructed at the Beaver Brook site. As the water supply will not be used for 16 years, it is considered that the single purpose alternative project would be constructed 16 years hence. A benefit-cost ratio of unity is assumed for this alternative project. Annual benefits of the multi-purpose project are discounted to reflect the present value of the alternative project. Annual charges are shown in Table No. C-III, First Costs and Annual Charges, Single Purpose Water Supply Project.

8. ALTERNATIVE PROJECTS. - A single purpose flood control dam at the project site is the alternative single purpose flood control project. This single purpose project is essentially the first stage of the multi-purpose project, but without the additional features to provide for future water supply. The single purpose project is described in Appendix C, Paragraph 3 of this Reconnaissance Interim Report.

A single purpose water supply dam at the project site is considered to be the alternative single purpose water supply project. Wells would be a possible alternative, but being more economical, wells will be developed first. In addition, there are no suitable locations where additional wells could be located. Use of Ashuelot River water would be possible, but storage would also be required since the entire natural flow is at times less than 4 m.g.d. The Beaver Brook site is considered the most favorable site for a surface water supply.

9. COST ALLOCATION ANALYSIS. - This cost allocation is based on the Separable Costs - Remaining Benefits Method in accordance with the Cost Allocation Agreement of 12 March 1954 among the Department of the Interior, Department of the Army, and the Federal Power Commission. The water supply storage is not needed immediately. It is considered that the alternative single purpose project would be built at the time it is needed and that the water supply benefits are equal to the present worth of the future benefits beginning at the time of its construction. Benefit cost ratio for this future project is taken at unity. Present day prices are used for the cost of future construction. While the dollar values will most likely be higher than at present, the exchange values in terms of labor and materials are considered constant. Cost allocation is developed in Tables No. D-III and D-IV. Results are tabulated in Table No. D-V.

10. COST ALLOCATION FOR SINGLE STAGE CONSTRUCTION. - In addition to the cost allocation for two stage construction, cost allocations were prepared for single stage construction with the water used immediately, in 10 years and in 16 years. For single stage construction, the alternative cost was taken as the cost of a water supply project constructed at this time. However, the benefits for the water supply feature were discounted for the period of non-use. Cost allocation for single stage construction is shown in Tables No. D-VI to D-XV inclusive. Federal and Non-Federal total costs are tabulated below:

SUMMARY OF COST ALLOCATIONS

Plan	Use of Water	Federal Cost	Non-Federal Cost	Total
Two Stage	in 16 years	$532,000	$803,000	$1,335,000
Single Stage	immediately	$423,000	$957,000	$1,380,000
Single Stage	in 10 years	$484,000	$896,000	$1,380,000
Single Stage	in 16 years	$523,000	$857,000	$1,380,000

Using the separable cost-remaining benefits method, the allocated cost of water supply storage, based on immediate use of water is $748,000. As this exceeds the estimate of $715,000 previously given in the data furnished the City, it is concluded that the City would again elect to defer the use of Beaver Brook Supply.

11. <u>SUBSTITUTION FOR FOURTH WELL.</u> - The fourth well (or the third new well) will be needed about ten years after completion of the project. As the pipeline connection will be longer, this well will be more costly than the other wells. Interest and amortization will cost about $7,800 and pumping costs $5,000 per year, making the cost for this well $12,800 per year. The allocated annual cost of water supply storage based on single stage construction and use of water in 10 years is about $30,200. Construction of the pipeline increases this cost to $44,200. This is $11,050 per M.G.D. If filtration is not required, this will be the most economical source of supply based on the unit cost per M.G.D. However, the use of the Beaver Brook project in 10 years would require that the City start paying immediately on the amount by which the cost of water supply storage exceeds 30 percent of the project cost. This amount is $76,000. Also at year 10, the City would have to invest $300,000 in the pipeline instead of $200,000 in the well. Consequently, on the basis of these cost allocations, the single stage construction is not competitive with the fourth well and two stage construction.

The cost allocation for two stage construction, with water supply used in 16 years, results in a Federal first cost of $532,000 for flood control. This represents a saving of $63,000 over the cost of a single purpose project.

Present worth of a two stage project with the second stage constructed in 10 years is $1,395,000 ($1,026,000 + 0.7441 x $496,000), or $15,000 more than for single stage construction. If the project could be used in about ten years as an alternative to the fourth well, single stage construction would then be more economical.

The annual cost of the well, $12,800, is $1,040 greater than the $11,660 interest and amortization on the Beaver Brook pipeline connection. If the Beaver Brook water supply cost did not increase as a result of using water in Year 10, use of Beaver Brook water would result in about the same cost as the fourth well and might be substituted for it.

TABLE NO. D-I

Beaver Brook Project
Cost Allocation Studies
Pertinent Data

Item	Unit	Multiple Purpose Project: Single Stage	Multiple Purpose Project - Two Stages: First Stage	Multiple Purpose Project - Two Stages: Second Stage	Alternative Single Purpose Projects: Flood Control	Alternative Single Purpose Projects: Water Supply
GENERAL						
Location		Beaver Brook, 1100 Ft. above new Rt.9 crossing	Same as single stage	Same as single stage	Same as multiple purpose	Same as multiple purpose
Drainage area	Sq.Mi.	6	6	6	6	6
RESERVOIR						
Elevation:						
Top of water supply pool	Ft.msl	808.5	-	808.5	-	808.5
Top of flood control pool	" "	820.0	810.0	820.0	810.0	-
Stream bed	" "	773.0	773.0	773.0	773.0	773.0
Reservoir area:						
Top of water supply pool	Ac.	220	-	220	-	220
Top of flood control pool	"	320	230	320	230	-
Storage capacity:						
Total	Ac.Ft.	6,200	3,200	6,200	3,200	3,000
Flood control	" "	3,200	3,200	3,200	3,200	-
Water supply	" "	3,000	-	3,000	-	3,000
DAM AND APPURTENANCES						
Dam:						
Type		Rolled earth fill with rock slope protection	Same as single stage	Same as first stage	Same as multiple purpose	Same as multiple purpose
Elevation, top of dam	Ft.msl	833	825.0	833.0	825.0	823.5
Length	Ft.	1,050	990	1,050	990.0	980.0
Height	"	60	52	60	52	50.5
Top width	"	20	20	20	20	20

TABLE NO. D-I (continued)

Item	Unit	Multiple Purpose Project	Multiple Purpose Project - Two Stages		Alternative Single Purpose Projects	
		Single Stage	First Stage	Second Stage	Flood Control	Water Supply
Spillway:						
Type		Uncontrolled Chute	Uncontrolled chute	Uncontrolled chute	Uncontrolled chute	Uncontrolled chute
Elevation of crest		820.0	810.0	820.0	810.0	808.5
Outlet Conduits:						
Type		Gate controlled pipe thru box conduit plus uncontrolled pipe thru spillway	Box conduit with orifice	Same as single stage	Ungated conduit under dam	Gate controlled conduit under dam
Number		2	1	2	1	1
Size		5'x5'box with pipe plus 27" diameter pipe thru spillway	5'x5'box with orifice	2'+dia. pipe plus 27" dia. pipe thru spillway	2'x3'box	5'x5'box

TABLE NO. D-II

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
SUMMARY OF CONSTRUCTION EXPENDITURES

2 Stage Construction — 16 Years between Stages — 50-Year Life

Permanent Features	Multiple Purpose Project: Specific Costs: Flood Control	Specific Costs: Water Supply	Joint Use Costs	Total Costs	Alternative single Purpose Projects: Flood Control	Water Supply
First Stage						
LANDS AND DAMAGES			$ 180,000	$ 180,000	$ 140,000	$ 134,000
RELOCATIONS			226,000	226,000	160,000	160,000
RESERVOIR			5,000	5,000	5,000	50,000
DAM AND APPURTENANCES		$ 25,000	590,000	615,000	590,000	666,000
Sub-Totals (First Stage)		$ 25,000	$1,001,000	$1,026,000	$ 895,000	$1,010,000
Second Stage						
RESERVOIR (additional clearing)		$ 45,000		$ 45,000		
DAM AND APPURTENANCES						
Raising Dam			$ 315,000	$ 315,000		
Water Supply Gates		54,000		54,000		
Intake Tower	$ 2,000	38,000		40,000		
Service Bridge	12,000	30,000		42,000		
Sub-Totals (Second Stage)	$14,000	$167,000	$ 315,000	$ 496,000		
Sub-Totals (Second Stage, Present Worth)	9,000	104,000	196,000	309,000		
TOTALS (1963 Prices)	$14,000	$192,000	$1,316,000	$1,522,000	$ 895,000	$1,010,000
TOTALS (Present Worth)	$ 9,000	$129,000	$1,197,000	$1,335,000		

TABLE NO. D-III

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
TRIAL ANALYSIS

2 Stage Construction — 16 Years between Stages — 50-Year Life

	Multiple Purpose Project: Specific Costs: Flood Control	Multiple Purpose Project: Specific Costs: Water Supply	Multiple Purpose Project: Joint Use Costs	Multiple Purpose Project: Total Costs	Alternative single Purpose Projects: Flood Control	Alternative single Purpose Projects: Water Supply	Water Supply (present worth)
INVESTMENT AND ANNUAL CHARGES							
Construction expenditures	$ 9,000	$129,000	$1,197,000	$1,335,000	$895,000	$1,010,000	$629,400
Interest during construction	-	-	-	-	-	-	-
Investment	9,000	129,000	1,197,000	1,335,000	895,000	1,010,000	629,400
Annual Charges							
Interest	$ 270	$ 3,870	$ 35,910	$ 40,050	$ 26,850	$ 30,300	$ 18,890
Amortization	80	1,140	10,620	11,840	7,940	8,960	5,580
Operation and Maintenance			4,530	4,530	3,000	3,570	2,220
Major replacements			940	940	450	1,000	620
Tax loss on land			1,520	1,520	1,440	1,400	870
Total Annual Charges	$ 350	$ 5,010	$ 53,520	$ 58,880	$ 39,680	$ 45,230	$ 28,180

ESTIMATED ALLOCATION	Flood Control	Water Supply	Total
a. Benefits	$102,200	$28,180	$130,380
b. Alternate cost	39,680	28,180	67,860
c. Benefits limited by alternate costs	39,680	28,180	67,860
d. Separable cost	30,700	19,200	49,900
e. Remaining benefits	8,980	8,980	17,960
f. Allocation of joint cost	4,490	4,490	8,980
g. Total allocation	35,190	23,690	58,880
h. Separable O & M & Major replacement cost	2,630	2,020	4,650
i. Allocation joint use O & M & Major replacement cost	410	410	820

TABLE NO. D-III (continued)

ESTIMATED ALLOCATION (cont)	Flood Control	Water Supply	Total
j. Loss of taxes	$ 1,045	$ 475	$ 1,520
k. Specific investment cost	350	5,010	5,360
l. Joint use investment cost	30,755	15,775	46,530
m. Percent of joint use investment cost	66.10	33.90	

TABLE NO. D-IV

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
ALLOCATION BY SEPARABLE COSTS-REMAINING BENEFITS METHOD

2 Stage Construction — 16 Years between Stages — 50-Year Life

	Flood Control	Water Supply	Total
1. ALLOCATION OF ANNUAL COSTS			
a. Benefits	$102,200	$28,180	$130,380
b. Alternate cost	39,680	28,180	67,860
c. Benefits limited by alternate cost	39,680	28,180	67,860
d. Separable cost	30,700	19,200	49,900
e. Remaining benefits	8,980	8,980	17,960
f. Allocated joint cost	4,490	4,490	8,980
g. Total allocation, economic costs	35,190	23,690	58,880
h. Loss of taxes	1,045	475	1,520
i. Total allocation, project costs	34,145	23,215	57,360
2. ALLOCATION OF OPERATION AND MAINTENANCE COSTS			
a. Separable cost	2,310	1,530	3,840
b. Allocated joint cost (in proportion to 1e)	345	345	690
c. Total allocation O & M	2,655	1,875	4,530
d. Specific costs	-	-	-
e. Allocated joint use costs	2,655	1,875	4,530
f. Ratio for allocation of joint use O & M	58.61	41.39	100.00
3. ALLOCATION OF MAJOR REPLACEMENTS			
a. Separable cost	320	490	810
b. Allocated joint cost	65	65	130
c. Total allocation, major replacements	385	555	940
4. ALLOCATION OF LOSS OF TAXES			
a. Separable cost	650	80	730
b. Allocated joint cost	395	395	790
c. Total allocation, loss of taxes	1,045	475	1,520
5. ALLOCATION OF INVESTMENT			
a. Annual investment cost	31,105	20,785	51,890
b. Percent of annual investment cost	59.944	40.056	100.0
c. Allocated investment	800,000	535,000	1,335,000

	Flood Control	Water Supply	Total
6. ALLOCATION OF CONSTRUCTION EXPENDITURES			
a. Specific investment	$ 9,000	$129,000	$ 138,000
b. Investment in joint use facilities	791,000	406,000	1,197,000
c. Interest during construction on joint use facilities	-	-	-
d. Construction expenditures in joint use facilities	791,000	406,000	1,197,000
e. Percent of construction expenditures in joint use facilities	66.08	33.92	100.00
f. Construction expenditures in specific facilities	9,000	129,000	138,000
g. Total construction expenditures	800,000	535,000	1,335,000
7. ALLOCATION TO USERS			
a. Cost of each purpose	800,000	535,000	1,335,000
b. Adjustment for lands, damages and relocations 66.08x406,000= 268,000	-268,000	+268,000	0
	Federal	Non-Federal	Total
c. Cost to each user (present worth)	532,000	803,000	1,335,000
d. Actual net expenditure, present and future	532,000	990,000	1,522,000

8. SAVINGS TO USERS User	Single Purpose Project	Allocated Cost of Multiple Purpose Project	Savings Dollars	Savings Percent
Federal, Flood Control, Construction	595,000	532,000	63,000	10.59
Local, Flood Control, Lands, etc.	300,000	268,000	32,000	10.67
Local, Water Supply, Construction	446,000*	397,000	49,000	10.99
Local, Water Supply, Lands, etc.	294,000	138,000	156,000	53.06

* Present worth, 716,000 x .6232 = 446,000

	Federal	Non-Federal
9. METHOD OF FINANCING		
Federal, first stage construction	$620,000	-
Local, lands, etc.	-	$406,000
Local, second stage, present worth	-	309,000
Local, reimbursement in years 17 to 50	-88,000	+88,000
Net first cost to users, present worth	532,000	803,000

TABLE NO. D-V

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
SUMMARY OF ALLOCATED COSTS

2 Stage Construction — 16 Years between Stages — 50-Year Life

	FEDERAL			NON-FEDERAL			TOTAL		
	Flood Control	Water Supply	Total	Flood Control	Water Supply	Total	Flood Control	Water Supply	Total
First Stage Construction	$595,000	$25,000	$620,000	$300,000	$106,000	$406,000	$895,000	$131,000	$1,026,000
Second Stage Construction (present worth)	$-63,000	$-25,000	$-88,000	$-32,000	$429,000	$397,000	$-95,000	$404,000	$ 309,000
Totals (present worth)	$532,000	0	$532,000	$268,000	$535,000	$803,000	$800,000	$535,000	$1,335,000

TABLE NO. D-VI

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
SUMMARY OF CONSTRUCTION EXPENDITURES

Single Stage Construction

	Multiple Purpose Project				Alternative Single Purpose Projects	
	Specific Costs					
Project Features	Flood Control	Water Supply	Joint Use Costs	Total Costs	Flood Control	Water Supply
LANDS AND DAMAGES			$ 180,000	$ 180,000	$140,000	$ 134,000
RELOCATIONS			226,000	226,000	160,000	160,000
RESERVOIR		$ 45,000	5,000	50,000	5,000	50,000
DAM AND APPURTENANCES			788,000	788,000	590,000	666,000
Water Supply Gates		54,000	-	54,000		
Intake Tower	$ 2,000	38,000	-	40,000		
Service Bridge	12,000	30,000	-	42,000		
TOTALS	$14,000	$167,000	$1,199,000	$1,380,000	$895,000	$1,010,000

TABLE NO. D-VII

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
TRIAL ANALYSIS

Single Stage Construction — 50-Year Life
Use of Water In 16 Years

	Multiple Purpose Project				Alternative single Purpose Projects		Water Supply (present worth)
	Specific Costs						
	Flood Control	Water Supply	Joint Use Costs	Total Costs	Flood Control	Water Supply	
INVESTMENT AND ANNUAL CHARGES							
Construction expenditures	$14,000	$167,000	$1,199,000	$1,380,000	$895,000	$1,010,000	$629,400
Interest during construction	-	-	-	-	-	-	-
Investment	14,000	167,000	1,199,000	1,380,000	895,000	1,010,000	629,400
Annual Charges							
Interest .03	$ 420	$ 5,010	$ 35,970	$ 41,400	$ 26,850	$ 30,300	$ 18,890
Amortization	120	1,480	10,640	12,240	7,940	8,960	5,580
Operation and Maintenance			5,000	5,000	3,000	3,570	2,220
Major replacements			1,400	1,400	450	1,000	620
Tax Loss on Land			1,600	1,600	1,440	1,400	870
Total Annual Charges	$ 540	$ 6,490	$ 54,610	$ 61,640	$ 39,680	$ 45,230	$ 28,180

ESTIMATED ALLOCATION	Flood Control	Water Supply	Total
a. Benefits	$ 102,000	$ 28,180	$130,380
b. Alternate cost	39,680	45,230	84,910
c. Benefits limited by alternate costs	39,680	28,180	67,860
d. Separable cost	16,410	21,960	38,370
e. Remaining benefits	23,270	6,220	29,490
f. Allocation of joint cost	18,360	4,910	23,270
g. Total allocation	34,770	26,870	61,640

TABLE NO. D-VII (continued)

ESTIMATED ALLOCATION (cont)	Flood Control	Water Supply	Total
h. Separable O & M & Major Replacement Cost	$ 1,830	$ 2,950	$ 4,780
i. Allocation joint use O & M & Major Replacement Cost	1,280	340	1,620
j. Loss of Taxes	1,180	420	1,600
k. Specific investment cost	540	6,490	7,030
l. Joint use investment cost	29,940	16,670	46,610
m. Percent of joint use investment cost	64.24	35.76	100.0

TABLE NO. D-VIII

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
ALLOCATION BY SEPARABLE COSTS-REMAINING BENEFITS METHOD

Single Stage Construction — 50-Year Life

Use of Water In 16 Years

	Flood Control	Water Supply	Total
1. ALLOCATION OF ANNUAL COSTS			
a. Benefits	$102,200	$28,180	$130,380
b. Alternate cost	39,680	45,230	84,910
c. Benefits limited by alternate cost	39,680	28,180	67,860
d. Separable cost	16,410	21,960	38,370
e. Remaining benefits	23,270	6,220	29,490
f. Allocated joint cost	18,360	4,910	23,270
g. Total allocation, economic costs	34,770	26,870	61,640
h. Loss of taxes	1,180	420	1,600
i. Total allocation, project costs	33,590	26,450	60,040
2. ALLOCATION OF OPERATION AND MAINTENANCE COSTS			
a. Separable cost	$ 1,430	$ 2,000	$ 3,430
b. Allocated joint cost	1,240	330	1,570
c. Total allocation O & M	2,670	2,330	5,000
d. Specific Costs	-	-	-
e. Allocated joint use costs	2,670	2,330	5,000
f. Ratio for allocation of joint use O & M	53.40	46.60	100.0
3. ALLOCATION OF MAJOR REPLACEMENTS			
a. Separable cost	$ 400	$ 950	$ 1,350
b. Allocated joint cost	40	10	50
c. Total allocation, major replacements	440	960	1,400
4. ALLOCATION OF LOSS OF TAXES			
a. Separable cost	$ 200	$ 160	$ 360
b. Allocated joint cost	980	260	1,240
c. Total allocation, loss of taxes	1,180	420	1,600
5. ALLOCATION OF INVESTMENT			
a. Annual investment cost	$ 30,480	$23,160	53,640
b. Percent of annual investment cost	56.82	43.18	100.0
c. Allocated investment	784,000	596,000	$1,380,000
6. ALLOCATION OF CONSTRUCTION EXPENDITURES			
a. Specific investment	$ 14,000	$167,000	$ 181,000
b. Investment in joint use facilities	770,000	429,000	1,199,000
c. Interest during construction on joint use facilities	-	-	-

TABLE NO. D-VIII (continued)

	Flood Control	Water Supply	Total
6. ALLOCATION OF CONSTRUCTION EXPENDITURES (cont)			
d. Construction expenditures in joint use facilities	$770,000	$429,000	$1,199,000
e. Percent of construction expenditures in joint use facilities	64.22	35.78	100.0
f. Construction expenditures in specific facilities	14,000	167,000	181,000
g. Total construction expenditures	784,000	596,000	1,380,000
7. ALLOCATION TO USERS			
a. Cost of each purpose	$784,000	$596,000	$1,380,000
b. Adjustment for lands, damages, and relocations 64.22 x 406,000	-261,000	+261,000	
c. Cost to each user	Federal	Non-Federal	
Actual net expenditure	523,000	857,000	

8. SAVINGS TO USERS	Single Purpose Project	Allocated Cost of Multiple Purpose Project	Savings Dollars	Savings Percent
USER				
Federal,Flood Control,Construction	$595,000	$523,000	$ 72,000	12.10
Local,Flood Control,Lands,etc.	300,000	261,000	39,000	13.00
Local,Water Supply,Construction	446,000*	451,000	-5,000	-1.12
Local,Water Supply,Lands,etc.	294,000	145,000	149,000	50.68

* Present Worth, $716,000 x .6232 = $446,000

9. METHOD OF FINANCING	FEDERAL	NON-FEDERAL
Federal, Construction	$974,000	-
Local, Lands, etc.	-	$406,000
Local, 30% Reimbursement	-414,000	414,000
Local, Immediate Obligation	-37,000	37,000
Net First Cost to Users	$523,000	$857,000

TABLE NO. D-IX

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
SUMMARY OF ALLOCATED COSTS

Single Stage Construction — 50-Year Life

Use of Water In 16 Years

	FEDERAL			NON-FEDERAL			TOTAL		
	Flood Control	Water Supply	Total	Flood Control	Water Supply	Total	Flood Control	Water Supply	Total
Construction, cash outlay	$523,000	$451,000	$974,000	$ 0	$ 0	$ 0	$523,000	$451,000	$974,000
Lands, damages, & relocations	0	0	0	261,000	145,000	406,000	261,000	145,000	406,000
Reimbursement - 50-year period	0	-37,000	-37,000	0	+37,000	37,000	0	0	0
30 percent deferred reimbursement - 34-year period	0	-414,000	-414,000	0	+414,000	414,000	0	0	0
NET TOTALS	$523,000	0	$523,000	$261,000	596,000	$857,000	$784,000	$596,000	$1,380,000

TABLE NO. D-X

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
TRIAL ANALYSIS

Single Stage Construction — 50-Year Life
Use of Water Immediately

	Multiple Purpose Project: Specific Costs: Flood Control	Specific Costs: Water Supply	Joint Use Costs	Total Costs	Alternative single Purpose Projects: Flood Control	Alternative single Purpose Projects: Water Supply
INVESTMENT AND ANNUAL CHARGES						
Construction expenditures	$14,000	$167,000	$1,199,000	$1,380,000	$895,000	$1,010,000
Interest during construction	-	-	-	-	-	-
Investment	14,000	167,000	1,199,000	1,380,000	895,000	1,010,000
Annual Charges						
Interest	420	5,010	35,970	41,400	26,850	30,300
Amortization	120	1,480	10,640	12,240	7,940	8,960
Operation and Maintenance			6,000	6,000	3,000	3,570
Major Replacements			1,400	1,400	450	1,000
Tax loss on land			1,600	1,600	1,440	1,400
Total Annual Charges	$ 540	$ 6,490	$ 55,610	$ 62,640	$ 39,680	$ 45,230

ESTIMATED ALLOCATION	Flood Control	Water Supply	Total
a. Benefits	$102,200	$45,230	$147,430
b. Alternate costs	39,680	45,230	84,910
c. Benefits limited by alternate costs	39,680	45,230	84,910
d. Separable cost	17,410	22,960	40,370
e. Remaining benefits	22,270	22,270	44,540
f. Allocation of joint cost	11,135	11,135	22,270
g. Total allocation	28,545	34,095	62,640
h. Separable O & M & Major replacement cost	2,830	3,950	6,780

TABLE NO. D-X (continued)

	Flood Control	Water Supply	Total
ESTIMATED ALLOCATION (cont)			
i. Allocation of joint use O & M & Major Replacement Cost	$ 310	$ 310	$ 620
j. Loss of taxes	820	780	1,600
k. Specific investment cost	540	6,490	7,030
l. Joint use investment cost	24,045	22,565	46,610
m. Percent of joint use investment cost	51.59	48.41	100.0

TABLE NO. D-XI

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
ALLOCATION BY SEPARABLE COSTS-REMAINING BENEFITS METHOD

Single Stage Construction — 50-Year Life
Use of Water Immediately

	Flood Control	Water Supply	Total
1. ALLOCATION OF ANNUAL COSTS			
a. Benefits	$102,200	$45,230	$147,430
b. Alternate Cost	39,680	45,230	84,910
c. Benefits limited by alternate cost	39,680	45,230	84,910
d. Separable cost	17,410	22,960	40,370
e. Remaining benefits	22,270	22,270	44,540
f. Allocated joint cost	11,135	11,135	22,270
g. Total allocation, economic costs	28,545	34,095	62,640
h. Loss of taxes	820	780	1,600
i. Total allocation, project costs	27,725	33,315	61,040
2. ALLOCATION OF OPERATION AND MAINTENANCE COSTS			
a. Separable cost	$ 2,430	$ 3,000	$ 5,430
b. Allocated joint cost	285	285	570
c. Total allocation, O & M	2,715	3,285	6,000
d. Specific Costs	-	-	-
e. Allocated joint use costs	2,715	3,285	6,000
f. Ratio for allocation of joint use O & M	45.25	54.75	100.0
3. ALLOCATION OF MAJOR REPLACEMENTS			
a. Separable cost	$ 400	$ 950	$ 1,350
b. Allocated joint cost	25	25	50
c. Total allocation, major replacements	425	975	1,400
4. ALLOCATION OF LOSS OF TAXES			
a. Separable cost	$ 200	$ 160	$ 360
b. Allocated joint cost	620	620	1,240
c. Total allocation, loss of taxes	820	780	1,600
5. ALLOCATION OF INVESTMENT			
a. Annual investment cost	$ 24,585	$29,055	$ 53,640
b. Percent of annual investment cost	45.83	54.17	100.0
c. Allocated investment	632,000	748,000	1,380,000

TABLE NO. D-XI (continued)

	Flood Control	Water Supply	Total
6. ALLOCATION OF CONSTRUCTION EXPENDITURES			
a. Specific investment	$ 14,000	$167,000	$ 181,000
b. Investment in joint use facilities	618,000	581,000	1,199,000
c. Interest during construction on joint use facilities	-	-	-
d. Construction expenditures in joint use facilities	618,000	581,000	1,199,000
e. Percent of construction expenditures in joint use facilities	51.54	48,46	100.0
f. Construction expenditures in specific facilities	14,000	167,000	181,000
g. Total construction expenditures	632,000	748,000	1,380,000
7. ALLOCATION TO USERS			
a. Cost of each purpose	$632,000	$748,000	$1,380,000
b. Adjustment for lands, damages and relocations 406,000 x 51.54%	-209,000	+209,000	
c. Cost to each user	Federal	Non-Federal	
Actual net expenditure	423,000	957,000	

8. SAVINGS TO USERS	Single Purpose Project	Allocated Cost of Multiple Purpose Project	Savings Dollars	Savings Percent
USER				
Federal, Flood Control, Construction	$595,000	$423,000	$172,000	28.9
Local, Flood Control, Lands, etc.	300,000	209,000	91,000	30.33
Local, Water Supply, Construction	716,000	551,000	165,000	23.04
Local, Water Supply, Lands, etc.	294,000	197,000	97,000	32.99

9. METHOD OF FINANCING	FEDERAL	NON-FEDERAL
Federal, Construction	$974,000	$ -
Local, lands, etc.	-	406,000
Local, 30% Reimbursement	-414,000	+414,000
Local, immediate obligation	-137,000	+137,000
Net first cost to Users	$423,000	$957,000

TABLE NO. D-XII

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
SUMMARY OF ALLOCATED COSTS

Single Stage Construction — 50-Year Life
Use of Water Immediately

	FEDERAL			NON-FEDERAL			TOTAL		
	Flood Control	Water Supply	Total	Flood Control	Water Supply	Total	Flood Control	Water Supply	Total
Construction, cash outlay	$423,000	$551,000	$974,000	0	0	0	$423,000	$551,000	$974,000
Lands, Damages, & Relocations	0	0	0	$209,000	$197,000	$406,000	209,000	197,000	406,000
Reimbursement, 50-year period	0	-551,000	-551,000	0	+551,000	+551,000	0	0	0
NET TOTALS	$423,000	0	$423,000	$209,000	$748,000	$957,000	$632,000	$748,000	$1,380,000

TABLE NO. D-XIII

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
TRIAL ANALYSIS

Single Stage Construction — 50-Year Life
Use of Water In 10 Years

	Multiple Purpose Project: Specific Costs: Flood Control	Multiple Purpose Project: Specific Costs: Water Supply	Multiple Purpose Project: Joint Use Costs	Multiple Purpose Project: Total Costs	Alternative single Purpose Projects: Flood Control	Alternative single Purpose Projects: Water Supply	Water Supply (present worth)
INVESTMENT AND ANNUAL CHARGES							
Construction expenditures	$14,000	$167,000	$1,199,000	$1,380,000	$895,000	$1,010,000	$751,500
Interest during construction	-	-	-	-	-	-	-
Investment	14,000	167,000	1,199,000	1,380,000	895,000	1,010,000	751,500
Annual Charges							
Interest	420	5,010	35,970	41,400	26,850	30,300	22,550
Amortization	120	1,480	10,640	12,240	7,940	8,960	6,670
Operation and Maintenance			6,000	6,000	3,000	3,570	2,660
Major Replacements			1,400	1,400	450	1,000	740
Tax Loss on Land			1,600	1,600	1,440	1,400	1,040
Total Annual Charges	$540	$6,490	$55,610	$62,640	$39,680	$45,230	$33,660

ESTIMATED ALLOCATION	Flood Control	Water Supply	Total
a. Benefits	$102,200	$33,660	$135,000
b. Alternate cost	39,680	45,230	84,910
c. Benefits limited by alternate cost	39,680	33,660	73,340
d. Separable cost	17,410	22,960	40,370
e. Remaining benefits	22,270	10,700	32,970
f. Allocation of joint cost	15,040	7,230	22,270
g. Total allocation	32,450	30,190	62,640
h. Separable O & M & Major Replacement Cost	2,830	3,950	6,780

TABLE NO. D-XIII

	Flood Control	Water Supply	Total
ESTIMATED ALLOCATION (cont)			
i. Allocation of joint use O & M & Major Replacement Cost	$,415	$,205	$,620
j. Loss of taxes	1,040	560	1,600
k. Specific investment cost	,540	6,490	7,030
l. Joint use investment cost	27,625	18,985	46,610
m. Percent of joint use investment cost	59.27	40.73	100.0

TABLE NO. D-XIV

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
ALLOCATION BY SEPARABLE COSTS-REMAINING BENEFITS METHOD

Single Stage Construction 50-Year Life
Use of Water In 10 Years

	Flood Control	Water Supply	Total
1. ALLOCATION OF ANNUAL COSTS			
a. Benefits	$102,200	$33,660	$135,860
b. Alternate cost	39,680	45,230	84,910
c. Benefits limited by alternate cost	39,680	33,660	73,340
d. Separable cost	17,410	22,960	40,370
e. Remaining benefits	22,270	10,700	32,970
f. Allocated joint cost	15,040	7,230	22,270
g. Total allocation, economic costs	32,450	30,190	62,640
h. Loss of taxes	1,040	560	1,600
i. Total allocation - project costs	31,410	29,630	61,040
2. ALLOCATION OF OPERATION AND MAINTENANCE COSTS			
a. Separable cost	$ 2,430	$ 3,000	$ 5,430
b. Allocated joint cost	385	185	570
c. Total allocation, O & M	2,815	3,185	6,000
d. Specific costs	-	-	-
e. Allocated joint use costs	2,815	3,185	6,000
f. Ratio for allocation of joint use O & M	46.92	53.08	100.0
3. ALLOCATION OF MAJOR REPLACEMENTS			
a. Separable cost	$ 400	$ 950	$ 1,350
b. Allocated joint cost	30	20	50
c. Total allocation - major replacements	430	970	1,400
4. ALLOCATION OF LOSS OF TAXES			
a. Separable cost	$ 200	$ 160	$ 360
b. Allocated joint cost	840	400	1,240
c. Total allocation, loss of taxes	1,040	560	1,600
5. ALLOCATION OF INVESTMENT			
a. Annual investment cost	$ 28,165	$25,475	$ 53,640
b. Percent of annual investment cost	52.51	47.49	100.0
c. Allocated investment	725,000	655,000	1,380,000

TABLE NO. D-XIV (continued)

	Flood Control	Water Supply	Total
6. ALLOCATION OF CONSTRUCTION EXPENDITURES			
a. Specific investment	$ 14,000	$167,000	$ 181,000
b. Investment in joint use facilities	711,000	488,000	1,199,000
c. Interest during construction on joint use facilities	-	-	-
d. Construction expenditures in joint use facilities	711,000	488,000	1,199,000
e. Percent of construction expenditures in joint use facilities	59.30	40.70	100.0
f. Construction expenditures in specific facilities	14,000	167,000	181,000
g. Total construction expenditures	725,000	655,000	1,380,000
7. ALLOCATION TO USERS			
a. Cost of each purpose	$725,000	$655,000	$1,380,000
b. Adjustment for lands, damages & relocations $406,000 x 59.30%	-241,000	+241,000	
c. Cost to each user	Federal	Non-Federal	
Actual net expenditure	484,000	896,000	

8. SAVINGS TO USERS

USER	Single Purpose Project	Allocated Cost of Multiple Purpose Project	Savings Dollars	Savings Percent
Federal, Flood Control, Construction	$595,000	$484,000	$111,000	18.66
Local, Flood Control, Lands, etc.	300,000	241,000	59,000	19.67
Local, Water Supply, Construction	533,000*	490,000	43,000	8.07
Local, Water Supply, Lands, etc.	294,000	165,000	129,000	43.88

* $716,000 x .7441 = $533,000

9. METHOD OF FINANCING	FEDERAL	NON-FEDERAL
a. Federal, Construction	$974,000	$ -
b. Local, lands, etc.	-	406,000
c. Local, 30% reimbursement	-414,000	+414,000
d. Local, immediate obligation	- 76,000	+ 76,000
e. Net first cost to users	484,000	896,000

TABLE NO. D-XV

BEAVER BROOK PROJECT
COST ALLOCATION STUDIES
SUMMARY OF ALLOCATED COSTS

Single Stage Construction — 50-Year Life
10 Years Before Use of Water Supply

	FEDERAL			NON-FEDERAL			TOTAL		
	Flood Control	Water Supply	Total	Flood Control	Water Supply	Total	Flood Control	Water Supply	Total
Construction, cash outlay	$484,000	$490,000	$974,000	$ 0	$ 0	$ 0	$484,000	$490,000	$974,000
Lands, Damages, & Relocations	0	0	0	241,000	165,000	406,000	241,000	165,000	406,000
Reimbursement, 50-year period	0	-76,000	-76,000	0	+76,000	+76,000	0	0	0
30 Percent, Deferred reimbursement, 40-year period	0	-414,000	-414,000	0	+414,000	+414,000	0	0	0
NET TOTALS	$484,000	0	$484,000	$241,000	$655,000	$896,000	$725,000	$655,000	$1,380,000